

Larssen
Steel Sheet
Piling

SOUTH DURHAM
STEEL AND IRON COMPANY
LIMITED

J H Davies
— —

Larssen Steel Sheet Piling

Details of Sections with
technical information, tables
and other relevant details

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**SOUTH DURHAM
STEEL AND IRON COMPANY
LIMITED**

(Incorporating Cargo Fleet Iron Company Limited)

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Engineers

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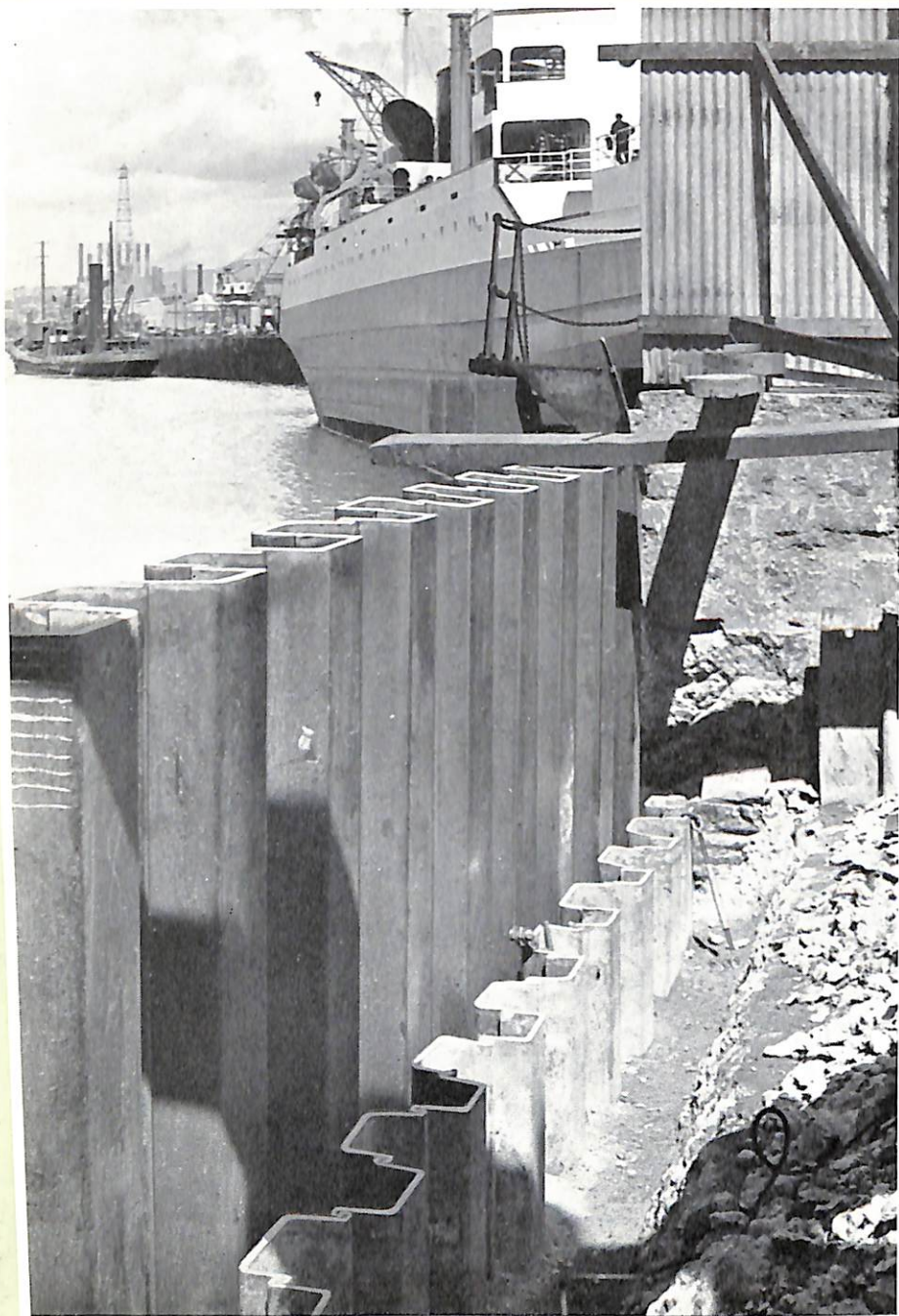
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Larssen Piling, newly-driven, during the extension of the West Jetty at the Scotstoun (Clyde) shipyard of Messrs. Yarrow & Co. Ltd. The Larssen Piling in the foreground, driven about 35 years before the picture was taken, was found to be in first-class condition and showed no sign of deterioration. Consulting Engineers: Kyle & Frew. Contractors: Melville Dundas & Whitson Ltd.



LARSSSEN STEEL SHEET PILING.

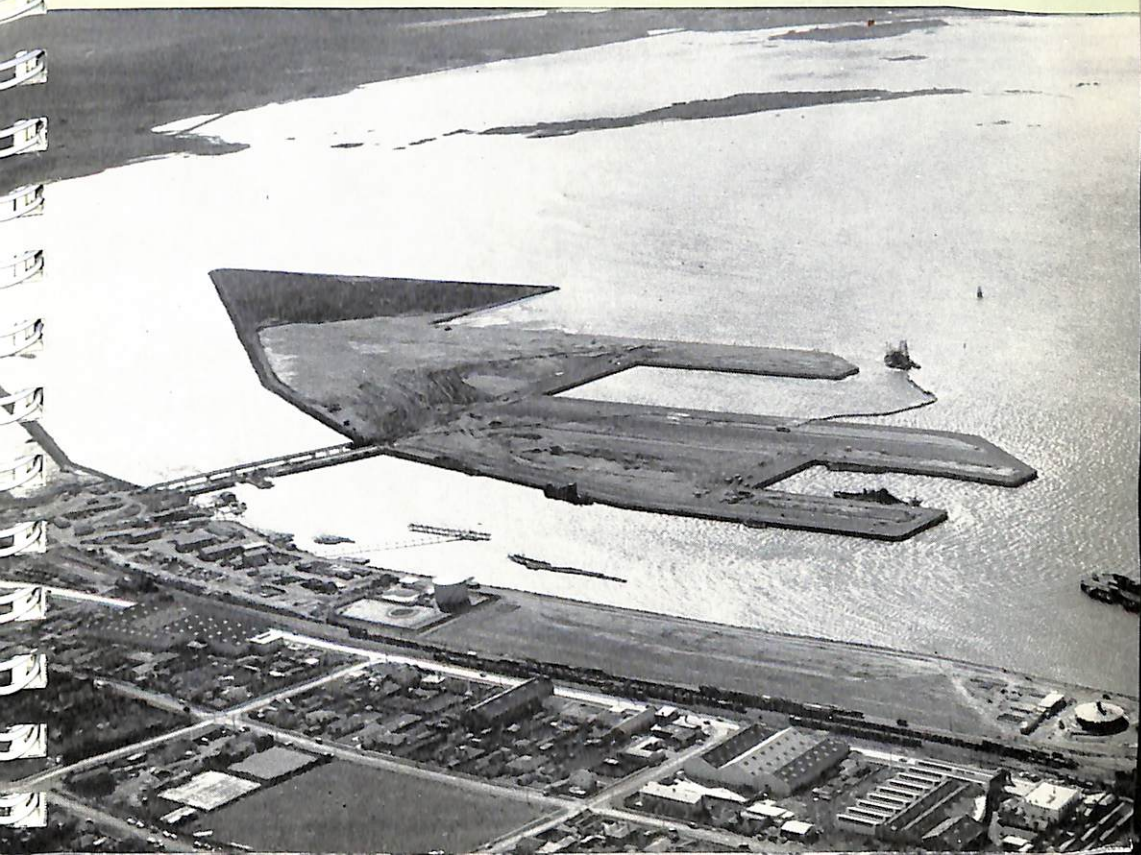
Larssen Steel Piling is designed on sound engineering principles. It provides the maximum in strength and durability at the lowest possible weight consistent with good driving qualities.

U-shaped in section, the piles have their greatest thicknesses concentrated at the maximum distance from the neutral axis, thus giving a high modulus of resistance.

Whilst two of the sections (Nos 1U and 10A), intended primarily for use in cut-off walls and shallow retaining walls where stresses are not severe, have uniform thickness throughout, the remainder have a greater thickness in the web, with the interlocks located on the neutral axis where stresses are least.

5

For the construction of Bluff Harbour, New Zealand, South Durham were privileged to supply over 7,100 tons of Larssen Piling to: The Societe Nationale de Travaux Publics; Societe Francaise d'Entreprises de Dragages et de Travaux Publics; Compagnie Belge de Chemins de Fer et d'Entreprises; Etudes et Entreprises.



The design of the interlocks makes for ease of pitching and driving and gives a series of closely-fitting joints the friction in which, combined with pile-to-ground friction, precludes the possibility of the piles sliding in relation to one another.

WATER-TIGHTNESS AND DURABILITY.

For the construction of quays, wharves, river frontages, dock and harbour works, cofferdams, permanent foundations, land reclamation installations and sea defence works, Larssen Steel Piling is the ideal civil engineering material.

It is particularly valuable in water-logged ground conditions. When seepage occurs, the solid particles in suspension immediately begin to form an effective seal in the interlocks thereby giving an exceptionally high degree of water-tightness.

Larssen Steel Piling offers a very high resistance to corrosion. The Sea Action Committee of the Institution of Civil Engineers has established, after 15-year tests, that the average annual corrosion rate on steel to B.S. 15 is .002 inches in fresh water and .003 inches in sea water. This resistance factor can be considerably increased if the piling is rolled from either copper-bearing steel or high-tensile rust-resisting steel, each of which the Company manufactures (see pages 50 and 51).

On right (above):

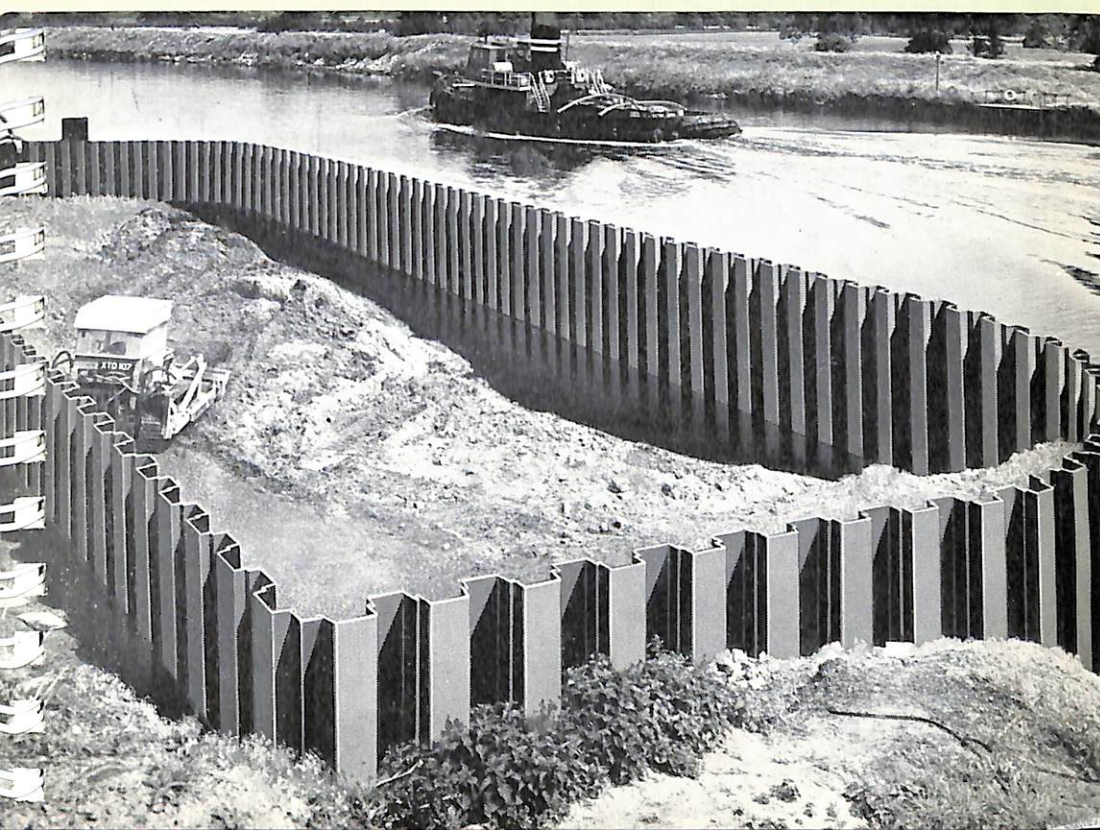
Larssen 4B Piling forming a continuous girdle to the foundation area for Dungeness Nuclear Power Station where it provided an effective barrier to the free flow of ground water. Engineers and Contractors: Sir Robert McAlpine & Sons Ltd.

On right (below):

Larssen Piling Cofferdam for pier construction at Thelwall Bridge where the Preston to Manchester Motorway crosses the Manchester Ship Canal and the River Mersey. Engineer: James Drake, B.Sc., M.I.C.E., M.I.Mun.E., F.I.H.E., Lancashire County Surveyor and Bridge-master. Contractors: L. Fairclough Ltd.



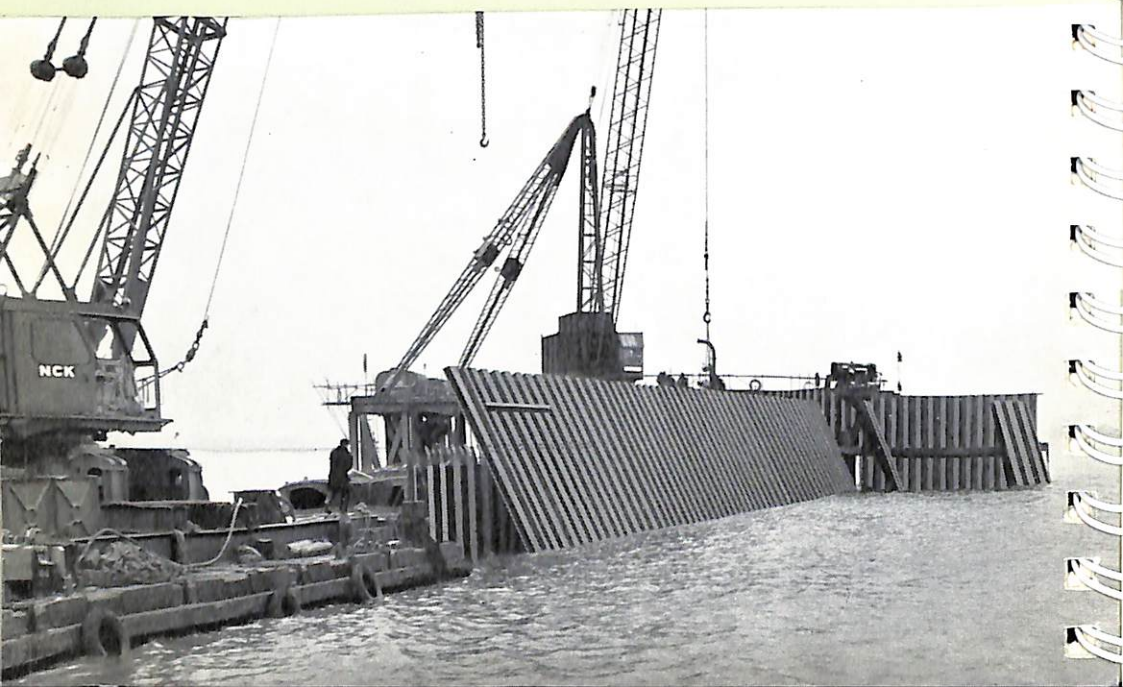
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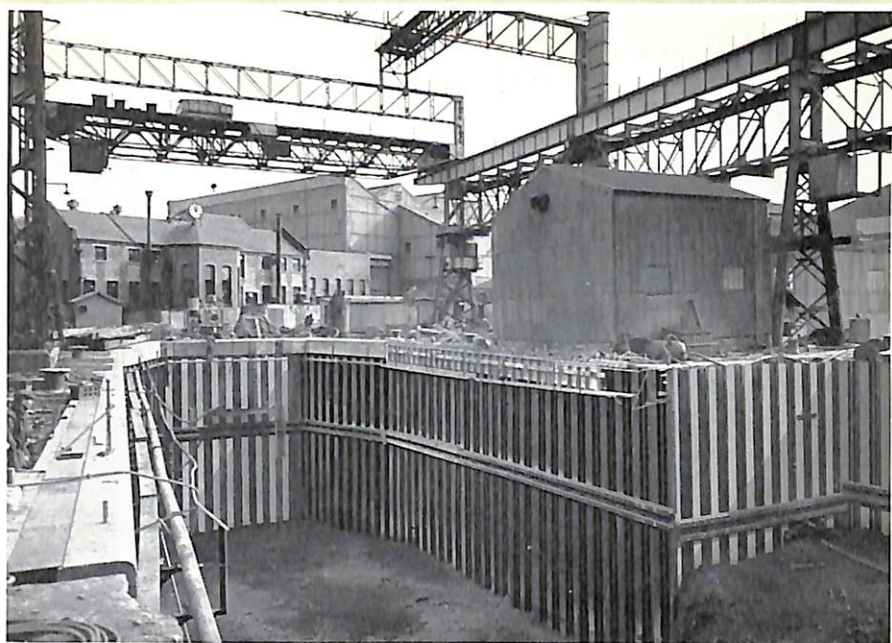




Above: Water Intake cofferdam of Larssen piling, No. 3 Section, during extensions for the South Eastern Gas Board at East Greenwich. Engineers: The Central Construction Department, South Eastern Gas Board. Contractors: The Demolition & Construction Co. Ltd.

Below: Raked Barrier Wall and Inlet and Outlet Shafts of Larssen Piling at Bradwell Nuclear Power Station, Essex. Supporting piles shown on right were removed on completion of shaft construction. Engineers and Contractors: Sir Robert McAlpine & Sons Ltd.



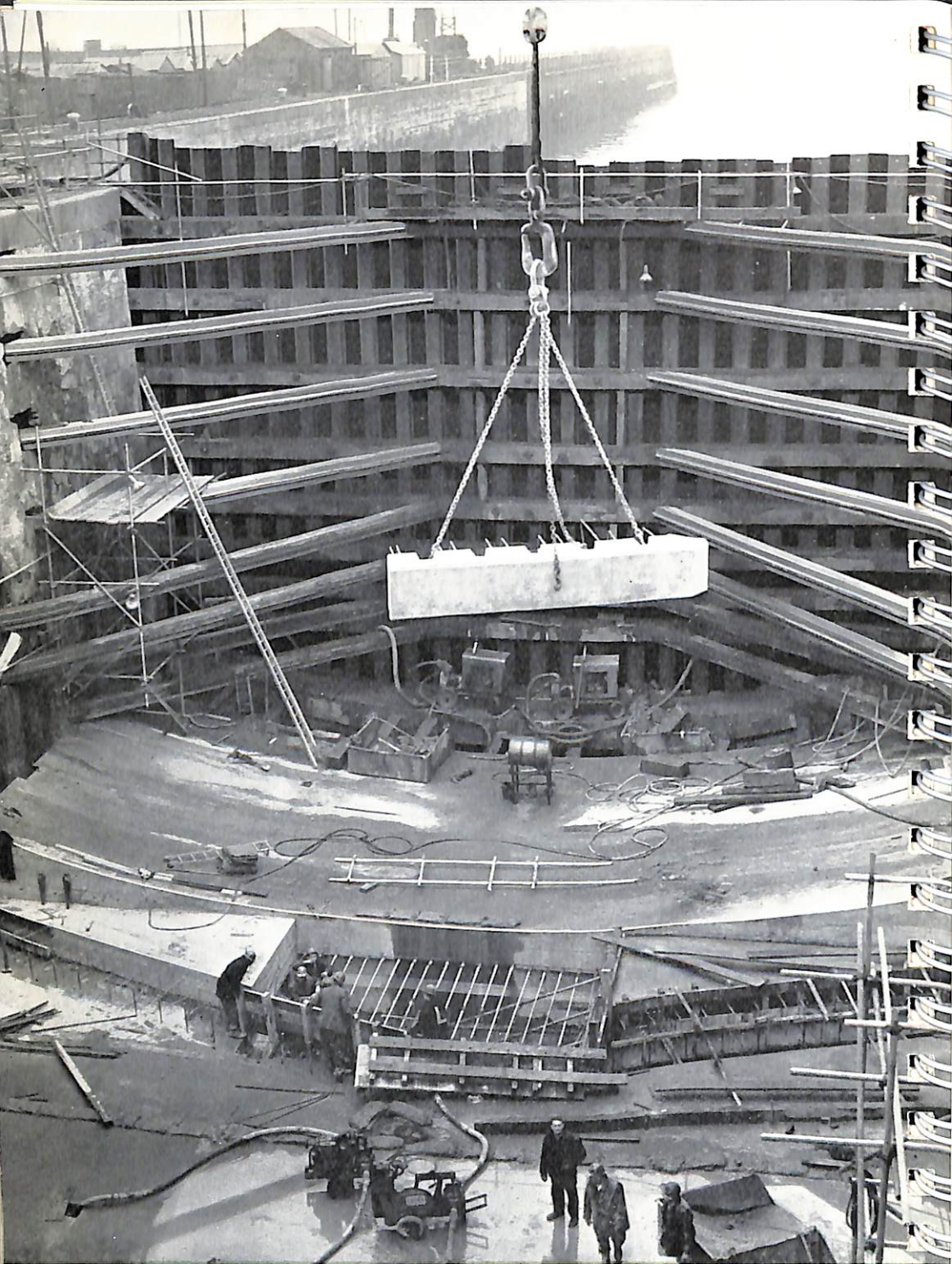


Larsen piling dock construction during the extension of fitting-out facilities for Yarrow & Co. Ltd., Scotstoun, Glasgow. Consulting Engineers: Kyle & Frew. Contractors: Melville, Dundas & Whitson Ltd.

ECONOMY.

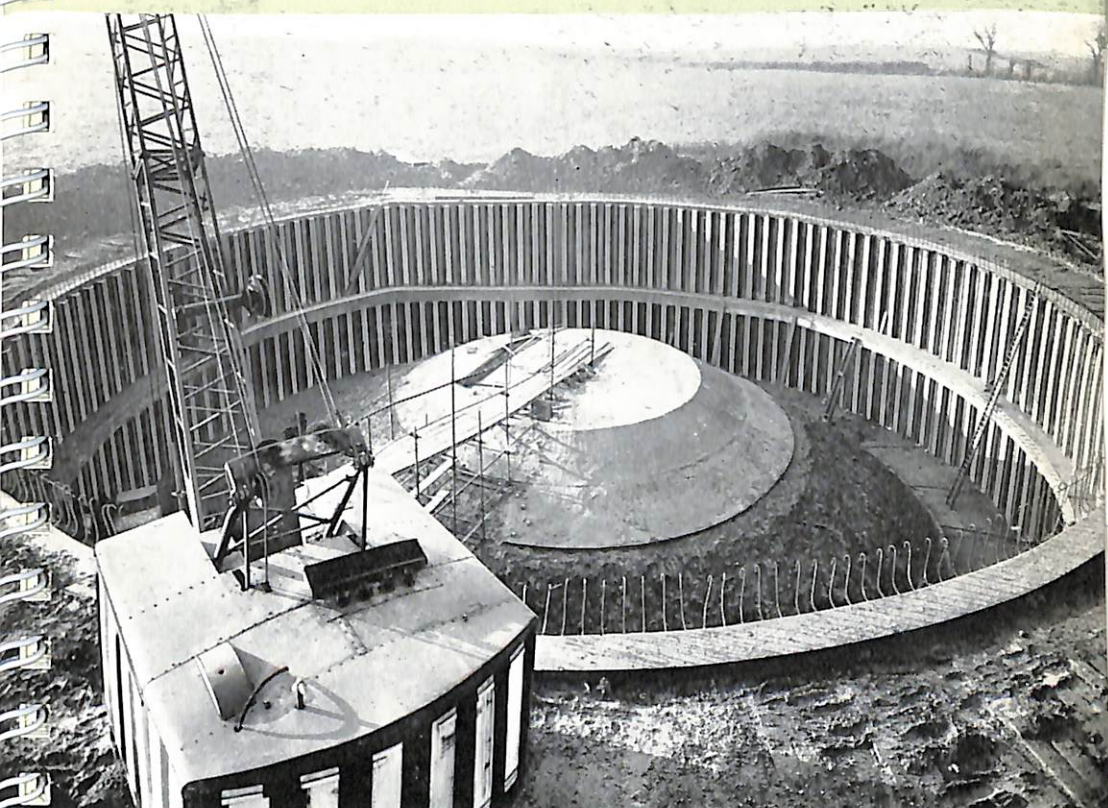
An extensive range of sections in widely differing sizes and weights, as shown in the table on page 15 enables the most economical choice to be made to suit the nature and requirements of any given contract. If occasion demands, the range can be extended subject to tonnage inducement being adequate.

The ease with which Larsen Steel Piling can be driven, even in difficult ground, reduces working time to a minimum. In addition, where piling, having fulfilled its purpose as a protection for permanent construction, is required to be withdrawn for re-use, it can be easily extracted without distortion.



Temporary cut-off wall of Larssen piling covering dock gate construction at Portishead, Somerset, showing Larssen box piles in use as struts. Consulting Engineer: T. L. Martin, M.I.C.E., Chief Engineer, Port of Bristol Authority. Contractors: John Laing & Son Ltd.

Larssen piling forming circular foundations for Gasholder for the North Thames Gas Board at Rayleigh, Essex. Contractors: W. & C. French Ltd.



MANUFACTURE.

In the United Kingdom, Larssen piling is manufactured solely by the South Durham Steel and Iron Company Limited at their Cargo Fleet steel works at Middlesbrough in the North Riding of Yorkshire. Whilst regular rollings are designed to ensure an adequate supply of the material it is always advantageous if customers can notify their requirements as far as possible in advance so that forward rolling programmes can be suitably arranged.

TECHNICAL ADVICE AND ASSISTANCE.

Whilst the principles governing the use of the various Larssen sections are well known, the nature of the work to be undertaken and the character of the ground have important bearings on the choice of section and the design of the proposed piling structure.

To ensure economy in the use of materials while maintaining the margin of safety which is essential in all civil engineering operations, skill based on sound engineering practice should be employed.

To assist engineers and contractors engaged in the development of projects involving the use of Larssen piling, the South Durham Steel and Iron Company Limited maintains a permanent staff of designers for consultation and the design of Larssen piling structures.

This design and technical staff is attached to the South Durham Constructional Department which has its headquarters at the Malleable Works at Stockton-on-Tees. Initial contact should however be made through the Company's Central Sales Office at Cargo Fleet Iron Works, Middlesbrough.

QUALITIES OF STEEL.

Larssen piling is rolled from steel manufactured by the Siemens-Martin Open-Hearth process and is obtainable in the following grades:

Quality	Ultimate Strength tons/ sq. inch	Yield Stress tons/ sq. inch	Minimum Elongation on 8 inches	
			Sections $\frac{3}{8}$ " thick and over	Sections under $\frac{3}{8}$ " thick
Steel to B.S. 15	28/33	16*	20%	16%
"Carfleco-Noncorr" copper-bearing steel (with 0.25-0.35% of copper to increase rust resistance)	28/33	16*		
Steel to B.S. 24, Part 6, 1957 (Section 2, Grade 621)	28/33	—	20%	20%
Medium tensile steel	33/38	20†	20%	16%
"Atlantes" high tensile rust resisting steel	37/43	23	18%	14%

* In the case of Larssen Sections 5 and 6, the Yield Stress is 15 tons per sq. inch.

† In the case of Larssen Sections 5 and 6, the Yield Stress is 19 tons per sq. inch.

RECOMMENDED WORKING STRESSES IN TONS PER SQ. INCH.

Class of work	Mild Steel	Medium tensile steel		High tensile steel
		Up to 4 B	Over 4 B	
Permanent	8.0	10.5	10.0	11.0
Temporary	10.0	13.0	12.0	14.0

PROTECTION.

Piles intended for permanent work should be coated with tar to B.S. 1070-1956, Type 2, before driving and the coating renewed on exposed parts of the piling from time to time.

Other coatings to customers' special requirements by arrangement.

ROLLING MARGINS.

Rolling margins as follows are required:

4% over and $2\frac{1}{2}$ % under theoretical weight.

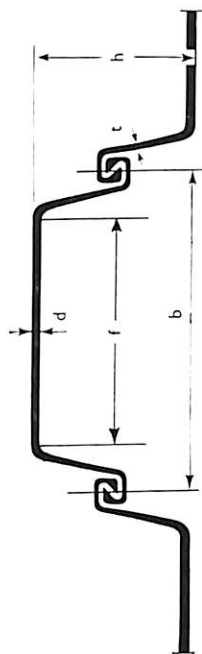
3" over and 2" under on length.

INTERLOCKING SECTIONS	
The following table shows the various LARSEN SECTIONS which will interlock	
SECTION NUMBER	INTERLOCKS WITH SECTIONS NUMBERED
1A	1B, 1GB, 1U, 2 & 2B
* 1B	1A, 1GB, 1U, 2 & 2B
1GB	1A, 1B, 1U, 2 & 2B
1U	1A, 1B, 1GB, 2 & 2B
2	1A, 1B, 1GB, 1U, 2B, 3, 3B, 4A & 10A
2B	1A, 1B, 1GB, 1U, 2, 3, 3B, 4A & 10A
3	2, 2B, 3B & 4A
3B	2, 2B, 3 & 4A
4A	2, 2B, 3 & 3B
4B	5 & 6
5	4B & 6
6	4B & 5
10A	2 & 2B

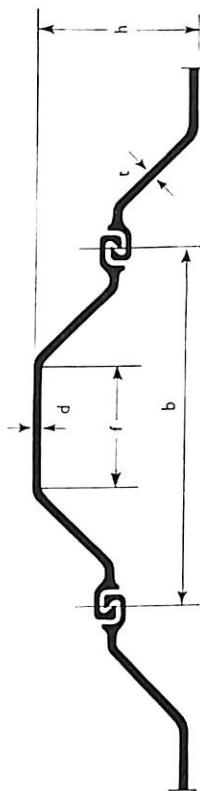
* Not yet available

Larssen Steel Sheet Piling:

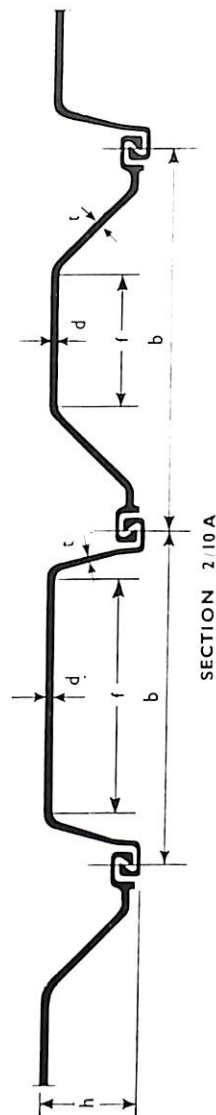
WEIGHTS AND PROPERTIES OF SECTIONS.



SECTIONS 1A, 1B, 1GB, 1U, 2, 2B, 3, 3B, 4A, 4B, 5 & 6



SECTION 10A



SECTION 2/10A

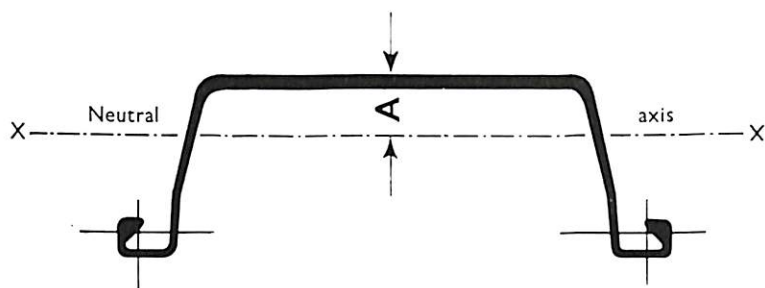
Section	b Inches	h Inches	d Inches	t Inches (nominal)	f Inches Flat of Web	Sectional Area Square Inches per foot of wall	Weight lbs. per linear foot	lbs. per sq. ft. (w)	Combined Mom. of Inertia ins. ⁴ per foot	Section Mod. ins. ³ per foot (z)	Ratio z — w
1 A	15 $\frac{3}{4}$	5 $\frac{1}{8}$	0.28	0.23	11 $\frac{7}{8}$	5.07	22.60	17.22	18.2	7.1	0.415
*1 B	15 $\frac{3}{4}$	7	0.28	0.25	12	5.39	24.05	18.32	36.6	10.5	0.570
1 GB	15 $\frac{3}{4}$	5 $\frac{1}{8}$	0.32	0.23	11 $\frac{7}{8}$	5.44	24.30	18.50	20.0	7.8	0.422
1 U	15 $\frac{3}{4}$	5 $\frac{1}{8}$	0.37	0.37	11 $\frac{7}{8}$	6.38	28.50	21.70	23.3	9.1	0.419
2	15 $\frac{3}{4}$	7 $\frac{7}{8}$	0.40	0.31	10 $\frac{5}{8}$	7.35	32.79	24.98	62.2	15.8	0.633
2 B	15 $\frac{3}{4}$	10 $\frac{5}{8}$	0.34	0.28	9 $\frac{3}{4}$	7.03	31.38	23.91	100.1	18.8	0.788
3	15 $\frac{3}{4}$	9 $\frac{3}{4}$	0.56	0.35	9 $\frac{3}{4}$	9.33	41.66	31.74	123.3	25.3	0.797
3 B	15 $\frac{3}{4}$	11 $\frac{1}{4}$	0.53	0.35	9 $\frac{1}{4}$	9.34	41.70	31.77	175.1	29.8	0.938
4 A	15 $\frac{3}{4}$	15	0.62	0.37	8 $\frac{5}{8}$	11.15	49.74	37.90	330.7	44.1	1.164
4 B	16 $\frac{9}{16}$	13 $\frac{1}{2}$	0.61	0.43	10 $\frac{1}{8}$	12.09	56.75	41.12	286.9	42.5	1.032
5	16 $\frac{9}{16}$	13 $\frac{1}{2}$	0.87	0.47	10 $\frac{1}{8}$	14.32	67.19	48.68	371.9	55.1	1.130
6	16 $\frac{17}{32}$	17 $\frac{5}{16}$	0.87	0.55	9 $\frac{3}{4}$	17.47	81.84	59.39	676.1	78.1	1.315
10 A	17 $\frac{3}{4}$	7 $\frac{7}{8}$	0.50	0.50	5 $\frac{1}{8}$	8.03	40.40	27.30	46.1	11.7	0.429
2/10 A	15 $\frac{3}{4}$ /17 $\frac{3}{4}$	4 $\frac{1}{2}$	0.40/0.50	0.31/0.50	10 $\frac{5}{8}$ /5 $\frac{1}{8}$	7.71	32.79/40.40	26.22	20.2	6.9	0.262

Sections 1 U and 10 A are designed with a uniform thickness of metal throughout for use where the load on the piling is low but maximum durability is required.

Section 2/10 A is a combination of alternate piles of Sections 2 and 10 A, producing a narrow wall suitable for trenches and excavations which can also be driven close to existing timbering or structures.

* Not yet available.

PROPERTIES OF SINGLE PILES.



Section No.	Area Square inches	Dimension A inches	Moment of inertia inches ⁴	Section Modulus inches ³
1 A	6.65	1.06	9.14	4.15
*1 B ...	7.07	1.43	17.68	6.34
1 GB ...	7.14	1.02	9.83	4.39
1 U ...	8.39	1.0	10.36	4.73
2 ...	9.64	1.61	29.32	9.45
2 B ...	9.23	2.38	51.54	13.54
3 ...	12.25	1.82	48.01	12.41
3 B ...	12.26	2.4	82.16	18.93
4 A ...	14.63	2.98	135.19	24.77
4 B ...	16.68	2.7	111.35	22.20
5 ...	19.76	2.4	137.19	25.81
6 ...	24.07	3.5	291.86	45.91
10 A ...	11.88	2.07	25.91	11.61

* Not yet available.

LARSEN STEEL SHEET PILING.

SECTIONS 1 A, 1 B, 1 GB, 1 U, 2, 2 B, 3, 3 B, and 4 A. LINEAR FEET COVERED WHEN INTERLOCKED.

Piles	0	1	2	3	4	5	6	7	8	9
0	—	1-31	2-62	3-94	5-25	6-56	7-87	9-19	10-50	11-81
10	13-12	14-44	15-75	17-06	18-37	19-69	21-00	22-31	23-62	24-94
20	26-25	27-56	28-87	30-19	31-50	32-81	34-12	35-44	36-75	38-06
30	39-37	40-69	42-00	43-31	44-62	45-94	47-25	48-56	49-87	51-19
40	52-50	53-81	55-12	56-44	57-75	59-06	60-37	61-69	63-00	64-31
50	65-62	66-94	68-25	69-56	70-87	72-19	73-50	74-81	76-12	77-44
60	78-75	80-06	81-37	82-69	84-00	85-31	86-62	87-94	89-25	90-56
70	91-87	93-19	94-50	95-81	97-12	98-44	99-75	101-06	102-37	103-69
80	105-00	106-31	107-62	108-94	110-25	111-56	112-87	114-19	115-50	116-81
90	118-12	119-44	120-75	122-06	123-37	124-69	126-00	127-31	128-62	129-94
100	131-25	132-56	133-87	135-19	136-50	137-81	139-12	140-44	141-75	143-06
200	262-50	263-81	265-12	266-44	267-75	269-06	270-37	271-69	273-00	274-31
300	393-75	395-06	396-37	397-69	399-00	400-31	401-62	402-94	404-25	405-56
400	525-00	526-31	527-62	528-94	530-25	531-56	532-87	534-19	535-50	536-81
500	656-25	657-56	658-87	660-19	661-50	662-81	664-12	665-44	666-75	668-06
600	787-50	788-81	790-12	791-44	792-75	794-06	795-37	796-69	798-00	799-31
700	918-75	920-06	921-37	922-69	924-00	925-31	926-62	927-94	929-25	930-56
800	1050-00	1051-31	1052-62	1053-94	1055-25	1056-56	1057-87	1059-19	1060-50	1061-81
900	1181-25	1182-56	1183-87	1185-19	1186-50	1187-81	1189-12	1190-44	1191-75	1193-06
1000	1312-50	1313-81	1315-12	1316-44	1317-75	1319-06	1320-37	1321-69	1323-00	1324-31

LARSEN STEEL SHEET PILING.

SECTIONS 4 B and 5. LINEAR FEET COVERED WHEN INTERLOCKED.

Piles	0	1	2	3	4	5	6	7	8	9
0	—	1:38	2:76	4:14	5:52	6:90	8:28	9:66	11:04	12:42
10	13:80	15:18	16:56	17:94	19:32	20:70	22:08	23:46	24:84	26:22
20	27:60	28:98	30:36	31:74	33:12	34:51	35:89	37:27	38:65	40:03
30	41:41	42:79	44:17	45:55	46:93	48:31	49:69	51:07	52:45	53:83
40	55:21	56:59	57:97	59:35	60:73	62:11	63:49	64:87	66:25	67:63
50	69:01	70:39	71:77	73:15	74:53	75:91	77:29	78:67	80:05	81:43
60	82:81	84:19	85:57	86:95	88:33	89:71	91:09	92:47	93:85	95:23
70	96:61	97:99	99:37	100:76	102:14	103:52	104:90	106:28	107:66	109:04
80	110:42	111:80	113:18	114:56	115:94	117:32	118:70	120:08	121:46	122:84
90	124:22	125:60	126:98	128:36	129:74	131:12	132:50	133:88	135:26	136:64
100	138:02	139:40	140:78	142:16	143:54	144:92	146:30	147:68	149:06	150:44
200	276:04	277:42	278:80	280:18	281:56	282:94	284:32	285:70	287:08	288:46
300	414:06	415:44	416:82	418:20	419:58	420:96	422:34	423:72	425:10	426:48
400	552:08	553:46	554:84	556:22	557:60	558:98	560:36	561:74	563:12	564:51
500	690:10	691:48	692:86	694:24	695:62	697:01	698:39	699:77	701:15	702:53
600	828:12	829:51	830:89	832:27	833:65	835:03	836:41	837:79	839:17	840:55
700	966:15	967:53	968:91	970:29	971:67	973:05	974:43	975:81	977:19	978:57
800	1104:17	1105:55	1106:93	1108:31	1109:69	1111:07	1112:45	1113:83	1115:21	1116:59
900	1242:19	1243:57	1244:95	1246:33	1247:71	1249:09	1250:47	1251:85	1253:23	1254:61
1000	1380:21	1381:59	1382:97	1384:35	1385:73	1387:11	1388:49	1389:87	1391:25	1392:63

LARSEN STEEL SHEET PILING.

SECTION 6.

LINEAR FEET COVERED WHEN INTERLOCKED.

Piles	0	1	2	3	4	5	6	7	8	9
0	—	1-38	2-76	4-13	5-51	6-89	8-27	9-64	11-02	12-40
10	13-78	15-15	16-53	17-91	19-29	20-66	22-04	23-42	24-80	26-17
20	27-55	28-93	30-31	31-68	33-06	34-44	35-82	37-20	38-57	39-95
30	41-33	42-71	44-08	45-46	46-84	48-22	49-59	50-97	52-35	53-73
40	55-10	56-48	57-86	59-24	60-61	61-99	63-37	64-75	66-12	67-50
50	68-88	70-26	71-64	73-01	74-39	75-77	77-15	78-52	79-90	81-28
60	82-66	84-03	85-41	86-79	88-17	89-54	90-92	92-30	93-68	95-05
70	96-43	97-81	99-19	100-56	101-94	103-32	104-70	106-08	107-45	108-83
80	110-21	111-59	112-96	114-34	115-72	117-10	118-47	119-85	121-23	122-61
90	123-98	125-36	126-74	128-12	129-49	130-87	132-25	133-63	135-00	136-38
100	137-76	139-14	140-52	141-89	143-27	144-65	146-03	147-40	148-78	150-16
200	275-52	276-90	278-28	279-65	281-03	282-41	283-79	285-16	286-54	287-92
300	413-28	414-66	416-04	417-41	418-79	420-17	421-55	422-92	424-30	425-68
400	551-04	552-42	553-80	555-17	556-55	557-93	559-31	560-68	562-06	563-44
500	688-80	690-18	691-56	692-93	694-31	695-69	697-07	698-44	699-82	701-20
600	826-56	827-94	829-32	830-69	832-07	833-45	834-83	836-20	837-58	838-96
700	964-32	965-70	967-08	968-45	969-83	971-21	972-59	973-96	975-34	976-72
800	1102-08	1103-46	1104-84	1106-21	1107-59	1108-97	1110-35	1111-72	1113-10	1114-48
900	1239-84	1241-22	1242-60	1243-97	1245-35	1246-73	1248-11	1249-48	1250-86	1252-24
1000	1377-60	1378-98	1380-36	1381-73	1383-11	1384-49	1385-87	1387-24	1388-62	1390-00

LARSEN STEEL SHEET PILING.

LINEAR FEET COVERED WHEN INTERLOCKED.

SECTION 10 A.

Piles	0	1	2	3	4	5	6	7	8	9
0	—	1-48	2-96	4-44	5-92	7-40	8-87	10-35	11-83	13-31
10	14-79	16-27	17-75	19-23	20-71	22-19	23-67	25-15	26-63	28-10
20	29-58	31-06	32-54	34-02	35-50	36-98	38-46	39-94	41-42	42-90
30	44-38	45-85	47-33	48-81	50-29	51-77	53-25	54-73	56-21	57-69
40	59-17	60-65	62-13	63-60	65-08	66-56	68-04	69-52	71-00	72-48
50	73-96	75-44	76-92	78-40	79-88	81-35	82-83	84-31	85-79	87-27
60	88-75	90-23	91-71	93-19	94-67	96-15	97-63	99-10	100-58	102-06
70	103-54	105-02	106-50	107-98	109-46	110-94	112-42	113-90	115-38	116-85
80	118-33	119-81	121-29	122-77	124-25	125-73	127-21	128-69	130-17	131-65
90	133-12	134-60	136-08	137-56	139-04	140-52	142-00	143-48	144-96	146-44
100	147-92	149-40	150-88	152-35	153-83	155-31	156-79	158-27	159-75	161-23
200	295-83	297-31	298-79	300-27	301-75	303-23	304-71	306-19	307-67	309-15
300	443-75	445-23	446-71	448-19	449-67	451-15	452-63	454-10	455-58	457-06
400	591-67	593-15	594-62	596-10	597-58	599-06	600-54	602-02	603-50	604-98
500	739-58	741-06	742-54	744-02	745-50	746-98	748-46	749-94	751-42	752-90
600	887-50	888-98	890-46	891-94	893-42	894-90	896-38	897-85	899-33	900-81
700	1035-42	1036-90	1038-38	1039-85	1041-33	1042-81	1044-29	1045-77	1047-25	1048-73
800	1183-33	1184-81	1186-29	1187-77	1189-25	1190-73	1192-21	1193-69	1195-17	1196-65
900	1331-25	1332-73	1334-21	1335-69	1337-17	1338-65	1340-13	1341-60	1343-08	1344-56
1000	1479-17	1480-65	1482-13	1483-60	1485-08	1486-56	1488-04	1489-52	1491-00	1492-48

LARSEN STEEL SHEET PILING.

COMBINED SECTION 2/10 A.

LINEAR FEET COVERED WHEN INTERLOCKED
(Commencing with a No. 2 Section).

Piles	0	1	2	3	4	5	6	7	8	9
0	—	1-31	2-79	4-10	5-58	6-90	8-37	9-69	11-17	12-48
10	13-96	15-27	16-75	18-06	19-54	20-85	22-33	23-65	25-12	26-44
20	27-92	29-23	30-71	32-02	33-50	34-81	36-29	37-60	39-08	40-40
30	41-87	43-19	44-67	45-98	47-46	48-77	50-25	51-56	53-04	54-35
40	55-83	57-15	58-62	59-94	61-42	62-73	64-21	65-52	67-00	68-31
50	69-79	71-10	72-58	73-90	75-37	76-69	78-17	79-48	80-96	82-27
60	83-75	85-06	86-54	87-85	89-33	90-65	92-12	93-44	94-92	96-23
70	97-71	99-02	100-50	101-81	103-29	104-60	106-08	107-40	108-87	110-19
80	111-67	112-98	114-46	115-77	117-25	118-56	120-04	121-35	122-83	124-15
90	125-62	126-94	128-42	129-73	131-21	132-52	134-00	135-31	136-79	138-10
100	139-58	140-90	142-37	143-69	145-17	146-48	147-96	149-27	150-75	152-06
200	279-17	280-48	281-96	283-27	284-75	286-06	287-54	288-85	290-33	291-65
300	418-75	420-06	421-54	422-85	424-33	425-65	427-12	428-44	429-92	431-23
400	558-33	559-65	561-12	562-44	563-92	565-23	566-71	568-02	569-50	570-81
500	697-92	699-23	700-71	702-02	703-50	704-81	706-29	707-60	709-08	710-40
600	837-50	838-81	840-29	841-60	843-08	844-40	845-87	847-19	848-67	849-98
700	977-08	978-40	979-87	981-19	982-67	983-98	985-46	986-77	988-25	989-56
800	1116-67	1117-98	1119-46	1120-77	1122-25	1123-56	1125-04	1126-35	1127-83	1129-15
900	1256-25	1257-56	1259-04	1260-35	1261-83	1263-15	1264-62	1265-94	1267-42	1268-73
1000	1395-83	1397-15	1398-62	1399-94	1401-42	1402-73	1404-21	1405-52	1407-00	1408-31

LARSEN STEEL SHEET PILING

SECTION 1 A.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.008	0.015	0.023	0.031	0.038	0.046	0.054	0.061	0.069
10	0.077	0.085	0.092	0.100	0.108	0.115	0.123	0.131	0.138	0.146
20	0.154	0.161	0.169	0.177	0.184	0.192	0.200	0.208	0.215	0.223
30	0.231	0.238	0.246	0.254	0.261	0.269	0.277	0.284	0.292	0.300
40	0.307	0.315	0.323	0.331	0.338	0.346	0.354	0.361	0.369	0.377
50	0.384	0.392	0.400	0.407	0.415	0.423	0.430	0.438	0.446	0.454
60	0.461	0.469	0.477	0.484	0.492	0.500	0.507	0.515	0.523	0.530
70	0.538	0.546	0.553	0.561	0.569	0.577	0.584	0.592	0.600	0.607
80	0.615	0.623	0.630	0.638	0.646	0.653	0.661	0.669	0.676	0.684
90	0.692	0.700	0.707	0.715	0.723	0.730	0.738	0.746	0.753	0.761
100	0.769	0.776	0.784	0.792	0.799	0.807	0.815	0.823	0.830	0.838
200	1.537	1.545	1.553	1.561	1.568	1.576	1.584	1.591	1.599	1.607
300	2.306	2.314	2.322	2.329	2.337	2.345	2.352	2.360	2.368	2.375
400	3.075	3.083	3.090	3.098	3.106	3.113	3.121	3.129	3.136	3.144
500	3.844	3.851	3.859	3.867	3.874	3.882	3.890	3.898	3.905	3.913
600	4.612	4.620	4.628	4.636	4.643	4.651	4.659	4.666	4.674	4.682
700	5.381	5.389	5.397	5.404	5.412	5.420	5.427	5.435	5.443	5.450
800	6.150	6.158	6.165	6.173	6.181	6.188	6.196	6.204	6.211	6.219
900	6.919	6.926	6.934	6.942	6.949	6.957	6.965	6.973	6.980	6.988
1000	7.687	7.695	7.703	7.711	7.718	7.726	7.734	7.741	7.749	7.757

LARSEN STEEL SHEET PILING.

* SECTION I B.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.008	0.016	0.025	0.033	0.041	0.049	0.057	0.065	0.074
10	0.082	0.090	0.098	0.106	0.115	0.123	0.131	0.139	0.147	0.155
20	0.164	0.172	0.180	0.188	0.196	0.204	0.213	0.221	0.229	0.237
30	0.245	0.254	0.262	0.270	0.278	0.286	0.294	0.303	0.311	0.319
40	0.327	0.335	0.344	0.352	0.360	0.368	0.376	0.384	0.393	0.401
50	0.409	0.417	0.425	0.434	0.442	0.450	0.458	0.466	0.474	0.483
60	0.491	0.499	0.507	0.515	0.524	0.532	0.540	0.548	0.556	0.564
70	0.573	0.581	0.589	0.597	0.605	0.613	0.622	0.630	0.638	0.646
80	0.654	0.663	0.671	0.679	0.687	0.695	0.703	0.712	0.720	0.728
90	0.736	0.744	0.752	0.761	0.769	0.777	0.785	0.793	0.802	0.810
100	0.818	0.826	0.834	0.842	0.851	0.859	0.867	0.875	0.883	0.892
200	1.636	1.644	1.652	1.660	1.669	1.677	1.685	1.693	1.701	1.709
300	2.454	2.462	2.470	2.478	2.486	2.495	2.503	2.511	2.519	2.527
400	3.272	3.280	3.288	3.296	3.304	3.313	3.321	3.329	3.337	3.345
500	4.090	4.098	4.106	4.114	4.122	4.130	4.139	4.147	4.155	4.163
600	4.907	4.916	4.924	4.932	4.940	4.948	4.957	4.965	4.973	4.981
700	5.725	5.734	5.742	5.750	5.758	5.766	5.774	5.783	5.791	5.799
800	6.543	6.551	6.560	6.568	6.576	6.584	6.592	6.600	6.609	6.617
900	7.361	7.369	7.377	7.386	7.394	7.402	7.410	7.418	7.426	7.435
1000	8.179	8.187	8.195	8.204	8.212	8.220	8.228	8.236	8.244	8.253

* Not yet available

LARSEN STEEL SHEET PILING.

WEIGHT IN TONS WHEN INTERLOCKED.

SECTION 1 GB.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.008	0.017	0.025	0.033	0.041	0.050	0.058	0.066	0.074
10	0.083	0.091	0.099	0.107	0.116	0.124	0.132	0.140	0.149	0.157
20	0.165	0.173	0.182	0.190	0.198	0.206	0.215	0.223	0.231	0.240
30	0.248	0.256	0.264	0.273	0.281	0.289	0.297	0.306	0.314	0.322
40	0.330	0.339	0.347	0.355	0.363	0.372	0.380	0.388	0.396	0.405
50	0.413	0.421	0.429	0.438	0.446	0.454	0.462	0.471	0.479	0.487
60	0.496	0.504	0.512	0.520	0.529	0.537	0.545	0.553	0.562	0.570
70	0.578	0.586	0.595	0.603	0.611	0.619	0.628	0.636	0.644	0.652
80	0.661	0.669	0.677	0.685	0.694	0.702	0.710	0.719	0.727	0.735
90	0.743	0.752	0.760	0.768	0.776	0.785	0.793	0.801	0.809	0.818
100	0.826	0.834	0.842	0.851	0.859	0.867	0.875	0.884	0.892	0.900
200	1.652	1.660	1.668	1.677	1.685	1.693	1.701	1.710	1.718	1.726
300	2.478	2.486	2.494	2.502	2.511	2.519	2.527	2.535	2.544	2.552
400	3.304	3.312	3.320	3.328	3.337	3.349	3.353	3.361	3.370	3.378
500	4.129	4.138	4.146	4.154	4.162	4.171	4.179	4.187	4.196	4.204
600	4.955	4.964	4.972	4.980	4.988	4.997	5.005	5.013	5.021	5.030
700	5.781	5.789	5.798	5.806	5.814	5.823	5.831	5.839	5.847	5.856
800	6.607	6.615	6.624	6.632	6.640	6.648	6.657	6.665	6.673	6.681
900	7.433	7.441	7.449	7.458	7.466	7.474	7.483	7.491	7.499	7.507
1000	8.259	8.267	8.275	8.284	8.292	8.300	8.308	8.317	8.325	8.333

LARSEN STEEL SHEET PILING.

SECTION I U.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0-010	0-019	0-029	0-039	0-048	0-058	0-068	0-078	0-087
10	0-097	0-107	0-116	0-126	0-136	0-145	0-155	0-165	0-174	0-184
20	0-194	0-203	0-213	0-223	0-233	0-242	0-252	0-262	0-271	0-281
30	0-291	0-300	0-310	0-320	0-329	0-339	0-349	0-358	0-368	0-378
40	0-388	0-397	0-407	0-417	0-426	0-436	0-446	0-455	0-465	0-475
50	0-484	0-494	0-504	0-513	0-523	0-533	0-543	0-552	0-562	0-572
60	0-581	0-591	0-601	0-610	0-620	0-630	0-639	0-649	0-659	0-668
70	0-678	0-688	0-698	0-707	0-717	0-727	0-736	0-746	0-756	0-765
80	0-775	0-785	0-794	0-804	0-814	0-823	0-833	0-843	0-853	0-862
90	0-872	0-882	0-891	0-901	0-911	0-920	0-930	0-940	0-949	0-959
100	0-969	0-978	0-988	0-998	1-008	1-017	1-027	1-037	1-046	1-056
200	1-938	1-947	1-957	1-967	1-976	1-986	1-996	2-005	2-015	2-025
300	2-906	2-916	2-926	2-935	2-945	2-955	2-964	2-974	2-984	2-993
400	3-875	3-885	3-894	3-904	3-914	3-923	3-933	3-943	3-953	3-962
500	4-844	4-853	4-863	4-873	4-883	4-892	4-902	4-912	4-921	4-931
600	5-813	5-822	5-832	5-842	5-851	5-861	5-871	5-880	5-890	5-900
700	6-781	6-791	6-801	6-810	6-820	6-830	6-839	6-849	6-859	6-868
800	7-750	7-760	7-769	7-779	7-789	7-798	7-808	7-818	7-828	7-837
900	8-719	8-728	8-738	8-748	8-758	8-767	8-777	8-787	8-796	8-806
1000	9-688	9-697	9-707	9-717	9-726	9-736	9-746	9-755	9-765	9-775

LARSEN STEEL SHEET PILING.

WEIGHT IN TONS WHEN INTERLOCKED.

SECTION 2.

Sq. ft.	0	1	2	3	4	5	6	7	8	9
0	—	0-011	0-022	0-033	0-045	0-056	0-067	0-078	0-089	0-100
10	0-112	0-123	0-134	0-145	0-156	0-167	0-178	0-190	0-210	0-212
20	0-223	0-234	0-245	0-256	0-268	0-279	0-290	0-301	0-312	0-323
30	0-335	0-346	0-357	0-368	0-379	0-390	0-401	0-413	0-424	0-435
40	0-446	0-457	0-468	0-480	0-491	0-502	0-513	0-524	0-535	0-546
50	0-558	0-569	0-580	0-591	0-602	0-613	0-625	0-636	0-647	0-658
60	0-669	0-680	0-691	0-703	0-714	0-725	0-736	0-747	0-758	0-769
70	0-781	0-792	0-803	0-814	0-825	0-836	0-848	0-859	0-870	0-881
80	0-892	0-903	0-914	0-926	0-937	0-948	0-959	0-970	0-981	0-993
90	1-004	1-015	1-026	1-037	1-048	1-059	1-071	1-082	1-093	1-104
100	1-115	1-126	1-138	1-149	1-160	1-171	1-182	1-193	1-204	1-216
200	2-230	2-242	2-253	2-264	2-275	2-286	2-297	2-308	2-320	2-331
300	3-346	3-357	3-368	3-379	3-390	3-401	3-413	3-424	3-435	3-446
400	4-461	4-472	4-483	4-494	4-505	4-517	4-528	4-539	4-550	4-561
500	5-576	5-587	5-598	5-609	5-621	5-632	5-643	5-654	5-665	5-676
600	6-691	6-702	6-714	6-725	6-736	6-747	6-758	6-769	6-780	6-792
700	7-806	7-818	7-829	7-840	7-851	7-862	7-873	7-884	7-896	7-907
800	8-922	8-933	8-944	8-955	8-966	8-977	8-989	9-000	9-011	9-022
900	10-037	10-048	10-059	10-070	10-081	10-093	10-104	10-115	10-126	10-137
1000	11-152	11-163	11-174	11-185	11-197	11-208	11-219	11-230	11-241	11-252

LARSEN STEEL SHEET PILING.

SECTION 2 B.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.011	0.021	0.032	0.043	0.053	0.064	0.075	0.085	0.096
10	0.107	0.117	0.128	0.139	0.149	0.160	0.171	0.181	0.192	0.203
20	0.213	0.224	0.235	0.246	0.256	0.267	0.278	0.288	0.299	0.310
30	0.320	0.331	0.342	0.352	0.363	0.374	0.384	0.395	0.406	0.416
40	0.427	0.438	0.448	0.459	0.470	0.480	0.491	0.502	0.512	0.523
50	0.534	0.544	0.555	0.566	0.576	0.587	0.598	0.608	0.619	0.630
60	0.640	0.651	0.662	0.672	0.683	0.694	0.704	0.715	0.726	0.737
70	0.747	0.758	0.769	0.779	0.790	0.801	0.811	0.822	0.833	0.843
80	0.854	0.865	0.875	0.886	0.897	0.907	0.918	0.929	0.939	0.950
90	0.961	0.971	0.982	0.993	1.003	1.014	1.025	1.035	1.046	1.057
100	1.067	1.078	1.089	1.099	1.110	1.121	1.131	1.142	1.153	1.163
200	2.135	2.145	2.156	2.167	2.177	2.188	2.199	2.210	2.220	2.231
300	3.202	3.213	3.224	3.234	3.245	3.256	3.266	3.277	3.288	3.298
400	4.270	4.280	4.291	4.302	4.312	4.323	4.334	4.344	4.355	4.366
500	5.337	5.348	5.358	5.369	5.380	5.390	5.401	5.412	5.422	5.433
600	6.404	6.415	6.426	6.436	6.447	6.458	6.468	6.479	6.490	6.500
700	7.472	7.482	7.493	7.504	7.514	7.525	7.536	7.547	7.557	7.568
800	8.539	8.550	8.561	8.571	8.582	8.593	8.603	8.614	8.625	8.635
900	9.607	9.617	9.628	9.639	9.649	9.660	9.671	9.681	9.692	9.703
1000	10.674	10.685	10.695	10.706	10.717	10.727	10.738	10.749	10.759	10.771

LARSEN STEEL SHEET PILING.

SECTION 3.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.014	0.028	0.043	0.057	0.071	0.085	0.099	0.113	0.128
10	0.142	0.156	0.170	0.184	0.198	0.213	0.227	0.241	0.255	0.269
20	0.283	0.298	0.312	0.326	0.340	0.354	0.368	0.383	0.397	0.411
30	0.425	0.439	0.453	0.468	0.482	0.496	0.510	0.524	0.538	0.553
40	0.567	0.581	0.595	0.609	0.623	0.638	0.652	0.666	0.680	0.694
50	0.708	0.723	0.737	0.751	0.765	0.779	0.793	0.808	0.822	0.836
60	0.850	0.864	0.879	0.893	0.907	0.921	0.935	0.949	0.964	0.978
70	0.992	1.006	1.020	1.034	1.049	1.063	1.077	1.091	1.105	1.119
80	1.133	1.148	1.162	1.176	1.190	1.204	1.219	1.233	1.247	1.261
90	1.275	1.289	1.304	1.318	1.332	1.346	1.360	1.374	1.389	1.403
100	1.417	1.431	1.445	1.459	1.474	1.488	1.502	1.516	1.530	1.544
200	2.834	2.848	2.862	2.876	2.891	2.905	2.919	2.933	2.947	2.961
300	4.251	4.265	4.279	4.293	4.308	4.322	4.336	4.350	4.364	4.378
400	5.668	5.682	5.696	5.710	5.725	5.739	5.753	5.767	5.781	5.795
500	7.085	7.099	7.113	7.127	7.141	7.156	7.170	7.184	7.198	7.212
600	8.502	8.516	8.530	8.544	8.558	8.573	8.587	8.601	8.615	8.629
700	9.919	9.933	9.947	9.961	9.975	9.990	10.004	10.018	10.032	10.046
800	11.336	11.350	11.364	11.378	11.392	11.407	11.421	11.435	11.449	11.463
900	12.753	12.767	12.781	12.795	12.809	12.823	12.838	12.852	12.866	12.880
1000	14.170	14.184	14.198	14.212	14.226	14.240	14.255	14.269	14.283	14.297

LARSEN STEEL SHEET PILING.

SECTION 3 B.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.014	0.028	0.043	0.057	0.071	0.085	0.099	0.113	0.128
10	0.142	0.156	0.170	0.184	0.199	0.213	0.227	0.241	0.255	0.269
20	0.284	0.298	0.312	0.326	0.340	0.355	0.369	0.383	0.397	0.411
30	0.425	0.440	0.454	0.468	0.482	0.496	0.511	0.525	0.539	0.553
40	0.567	0.582	0.596	0.610	0.624	0.638	0.652	0.667	0.681	0.695
50	0.709	0.723	0.738	0.752	0.766	0.780	0.794	0.808	0.823	0.837
60	0.851	0.865	0.879	0.894	0.908	0.922	0.936	0.950	0.964	0.979
70	0.993	1.007	1.021	1.035	1.050	1.064	1.078	1.092	1.106	1.120
80	1.135	1.149	1.163	1.177	1.191	1.206	1.220	1.234	1.248	1.262
90	1.276	1.291	1.305	1.319	1.333	1.347	1.362	1.376	1.390	1.404
100	1.418	1.432	1.447	1.461	1.475	1.489	1.503	1.518	1.532	1.546
200	2.837	2.851	2.865	2.879	2.893	2.908	2.922	2.936	2.950	2.964
300	4.255	4.269	4.283	4.297	4.312	4.326	4.340	4.354	4.368	4.383
400	5.673	5.687	5.702	5.716	5.730	5.744	5.758	5.772	5.787	5.801
500	7.092	7.106	7.120	7.134	7.148	7.162	7.177	7.191	7.205	7.219
600	8.510	8.524	8.538	8.552	8.567	8.581	8.595	8.609	8.623	8.637
700	9.928	9.942	9.956	9.971	9.985	9.999	10.013	10.027	10.042	10.056
800	11.346	11.361	11.375	11.389	11.403	11.417	11.432	11.446	11.460	11.474
900	12.765	12.779	12.793	12.807	12.821	12.836	12.850	12.864	12.878	12.892
1000	14.183	14.197	14.211	14.226	14.240	14.254	14.268	14.282	14.296	14.311

LARSEN STEEL SHEET PILING.

WEIGHT IN TONS WHEN INTERLOCKED.

SECTION 4 A.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.017	0.034	0.051	0.068	0.085	0.102	0.118	0.135	0.152
10	0.169	0.186	0.203	0.220	0.237	0.254	0.271	0.288	0.305	0.322
20	0.338	0.355	0.372	0.389	0.406	0.423	0.440	0.457	0.474	0.491
30	0.508	0.525	0.541	0.558	0.575	0.592	0.609	0.626	0.643	0.660
40	0.677	0.694	0.711	0.728	0.745	0.761	0.778	0.795	0.812	0.829
50	0.846	0.863	0.880	0.897	0.914	0.931	0.948	0.964	0.981	0.998
60	1.015	1.032	1.049	1.066	1.083	1.100	1.117	1.134	1.151	1.168
70	1.184	1.201	1.218	1.235	1.252	1.269	1.286	1.303	1.320	1.337
80	1.354	1.371	1.387	1.404	1.421	1.438	1.455	1.472	1.489	1.506
90	1.523	1.540	1.557	1.574	1.590	1.607	1.625	1.641	1.658	1.675
100	1.692	1.709	1.726	1.743	1.760	1.777	1.794	1.810	1.827	1.844
200	3.384	3.401	3.418	3.435	3.452	3.469	3.486	3.502	3.519	3.536
300	5.076	5.093	5.110	5.127	5.144	5.161	5.178	5.194	5.211	5.228
400	6.768	6.785	6.802	6.819	6.836	6.853	6.870	6.886	6.903	6.920
500	8.460	8.477	8.494	8.511	8.528	8.545	8.562	8.578	8.595	8.612
600	10.152	10.169	10.186	10.203	10.220	10.237	10.254	10.270	10.287	10.304
700	11.844	11.861	11.878	11.895	11.912	11.929	11.946	11.962	11.979	11.996
800	13.536	13.553	13.570	13.587	13.604	13.621	13.638	13.654	13.672	13.688
900	15.228	15.245	15.262	15.279	15.296	15.313	15.330	15.346	15.363	15.380
1000	16.920	16.937	16.954	16.971	16.988	17.005	17.022	17.038	17.055	17.072

LARSEN STEEL SHEET PILING.

SECTION 4 B.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.018	0.037	0.055	0.073	0.092	0.110	0.128	0.147	0.165
10	0.184	0.202	0.220	0.239	0.257	0.275	0.294	0.312	0.330	0.349
20	0.367	0.385	0.404	0.422	0.441	0.459	0.477	0.496	0.514	0.532
30	0.551	0.569	0.587	0.606	0.624	0.642	0.661	0.679	0.698	0.716
40	0.734	0.753	0.771	0.789	0.808	0.826	0.844	0.863	0.881	0.899
50	0.918	0.936	0.955	0.973	0.991	1.010	1.028	1.046	1.065	1.083
60	1.101	1.120	1.138	1.156	1.175	1.193	1.212	1.230	1.248	1.267
70	1.285	1.303	1.322	1.340	1.358	1.377	1.395	1.413	1.432	1.450
80	1.469	1.487	1.505	1.524	1.542	1.560	1.579	1.597	1.615	1.634
90	1.652	1.670	1.689	1.707	1.726	1.744	1.762	1.781	1.799	1.817
100	1.836	1.854	1.872	1.891	1.909	1.927	1.946	1.964	1.983	2.001
200	3.671	3.690	3.708	3.726	3.745	3.763	3.782	3.800	3.818	3.837
300	5.507	5.526	5.544	5.562	5.581	5.599	5.617	5.636	5.654	5.672
400	7.343	7.361	7.380	7.398	7.416	7.435	7.453	7.471	7.490	7.508
500	9.179	9.197	9.215	9.234	9.252	9.270	9.289	9.307	9.325	9.344
600	11.014	11.033	11.051	11.069	11.088	11.106	11.124	11.143	11.161	11.179
700	12.850	12.868	12.887	12.905	12.923	12.942	12.960	12.978	12.997	13.015
800	14.686	14.704	14.722	14.741	14.759	14.777	14.796	14.814	14.833	14.851
900	16.521	16.540	16.558	16.576	16.595	16.613	16.632	16.650	16.668	16.687
1000	18.357	18.375	18.394	18.412	18.431	18.449	18.467	18.486	18.504	18.522

LARSEN STEEL SHEET PILING.

WEIGHT IN TONS WHEN INTERLOCKED.

SECTION 5.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.022	0.043	0.065	0.087	0.109	0.130	0.152	0.174	0.196
10	0.217	0.239	0.261	0.282	0.304	0.326	0.348	0.369	0.391	0.413
20	0.435	0.456	0.478	0.500	0.522	0.543	0.565	0.587	0.608	0.630
30	0.652	0.674	0.695	0.717	0.739	0.761	0.782	0.804	0.826	0.848
40	0.869	0.891	0.913	0.934	0.956	0.978	1.000	1.021	1.043	1.065
50	1.087	1.108	1.130	1.152	1.173	1.195	1.217	1.238	1.260	1.282
60	1.304	1.326	1.347	1.369	1.391	1.412	1.434	1.456	1.478	1.499
70	1.521	1.543	1.565	1.586	1.608	1.630	1.652	1.673	1.695	1.717
80	1.739	1.760	1.782	1.804	1.825	1.847	1.869	1.891	1.912	1.934
90	1.956	1.978	1.999	2.021	2.043	2.064	2.086	2.108	2.130	2.151
100	2.173	2.195	2.217	2.238	2.260	2.282	2.304	2.325	2.347	2.369
200	4.346	4.368	4.390	4.412	4.433	4.455	4.477	4.498	4.520	4.542
300	6.520	6.541	6.563	6.585	6.607	6.628	6.650	6.672	6.693	6.715
400	8.693	8.715	8.736	8.758	8.780	8.801	8.823	8.845	8.867	8.888
500	10.866	10.888	10.909	10.931	10.953	10.975	10.996	11.018	11.040	11.062
600	13.039	13.061	13.083	13.104	13.126	13.148	13.170	13.191	13.213	13.235
700	15.212	15.234	15.256	15.278	15.299	15.321	15.343	15.365	15.386	15.408
800	17.386	17.407	17.429	17.451	17.473	17.494	17.516	17.538	17.559	17.581
900	19.559	19.581	19.602	19.624	19.646	19.667	19.689	19.711	19.733	19.754
1000	21.732	21.754	21.776	21.797	21.819	21.841	21.862	21.884	21.906	21.928

LARSEN STEEL SHEET PILING.

SECTION 6.

WEIGHT IN TONS WHEN INTERLOCKED.

Sq. ft.	0	1	2	3	4	5	6	7	8	9
0	—	0.027	0.053	0.080	0.106	0.133	0.159	0.186	0.212	0.239
10	0.265	0.292	0.318	0.345	0.371	0.398	0.424	0.451	0.477	0.504
20	0.530	0.557	0.583	0.610	0.636	0.663	0.689	0.716	0.742	0.769
30	0.795	0.822	0.848	0.875	0.901	0.928	0.954	0.981	1.008	1.034
40	1.061	1.087	1.114	1.140	1.167	1.193	1.220	1.246	1.273	1.299
50	1.326	1.352	1.379	1.405	1.432	1.458	1.485	1.511	1.538	1.564
60	1.591	1.617	1.644	1.670	1.697	1.723	1.750	1.776	1.803	1.829
70	1.856	1.882	1.909	1.935	1.962	1.988	2.015	2.042	2.068	2.095
80	2.121	2.148	2.174	2.201	2.227	2.254	2.280	2.307	2.333	2.360
90	2.386	2.413	2.439	2.466	2.492	2.519	2.545	2.572	2.598	2.625
100	2.651	2.678	2.704	2.731	2.757	2.784	2.810	2.837	2.863	2.890
200	5.303	5.329	5.356	5.382	5.409	5.435	5.462	5.488	5.515	5.541
300	7.954	7.981	8.007	8.034	8.060	8.087	8.113	8.140	8.166	8.193
400	10.605	10.632	10.658	10.685	10.711	10.738	10.764	10.791	10.817	10.844
500	13.257	13.283	13.310	13.336	13.363	13.389	13.416	13.442	13.469	13.495
600	15.908	15.935	15.961	15.988	16.014	16.041	16.067	16.094	16.120	16.147
700	18.559	18.586	18.612	18.639	18.665	18.692	18.718	18.745	18.771	18.798
800	21.211	21.237	21.264	21.290	21.317	21.343	21.370	21.396	21.423	21.449
900	23.862	23.889	23.915	23.942	23.968	23.995	24.021	24.048	24.074	24.101
1000	26.513	26.540	26.566	26.593	26.619	26.646	26.672	26.699	26.725	26.752

LARSEN STEEL SHEET PILING.

WEIGHT IN TONS WHEN INTERLOCKED.

SECTION 10 A.

Sq. ft.	0	1	2	3	4	5	6	7	8	9
0	—	0-012	0-024	0-037	0-049	0-061	0-073	0-085	0-098	0-110
10	0-122	0-134	0-146	0-158	0-171	0-183	0-195	0-207	0-219	0-232
20	0-244	0-256	0-268	0-280	0-293	0-305	0-317	0-329	0-341	0-353
30	0-366	0-378	0-390	0-402	0-414	0-427	0-439	0-451	0-463	0-475
40	0-488	0-500	0-512	0-524	0-536	0-548	0-561	0-573	0-585	0-597
50	0-609	0-622	0-634	0-646	0-658	0-670	0-683	0-695	0-707	0-719
60	0-731	0-743	0-756	0-768	0-780	0-792	0-804	0-817	0-829	0-841
70	0-853	0-865	0-878	0-890	0-902	0-914	0-926	0-938	0-951	0-963
80	0-975	0-987	0-999	1-012	1-024	1-036	1-048	1-060	1-073	1-085
90	1-097	1-109	1-121	1-133	1-146	1-158	1-170	1-182	1-194	1-207
100	1-219	1-231	1-243	1-255	1-268	1-280	1-292	1-304	1-316	1-328
200	2-438	2-450	2-462	2-474	2-486	2-498	2-511	2-523	2-535	2-547
300	3-656	3-668	3-681	3-693	3-705	3-717	3-729	3-742	3-754	3-766
400	4-875	4-887	4-899	4-912	4-924	4-936	4-948	4-960	4-973	4-985
500	6-094	6-106	6-118	6-130	6-143	6-155	6-167	6-179	6-191	6-203
600	7-313	7-325	7-337	7-349	7-361	7-373	7-386	7-398	7-410	7-422
700	8-531	8-543	8-556	8-568	8-580	8-592	8-604	8-617	8-629	8-641
800	9-750	9-762	9-774	9-787	9-799	9-811	9-823	9-835	9-848	9-860
900	10-969	10-981	10-993	11-005	11-017	11-030	11-042	11-054	11-066	11-078
1000	12-188	12-200	12-212	12-224	12-236	12-248	12-261	12-273	12-285	12-297

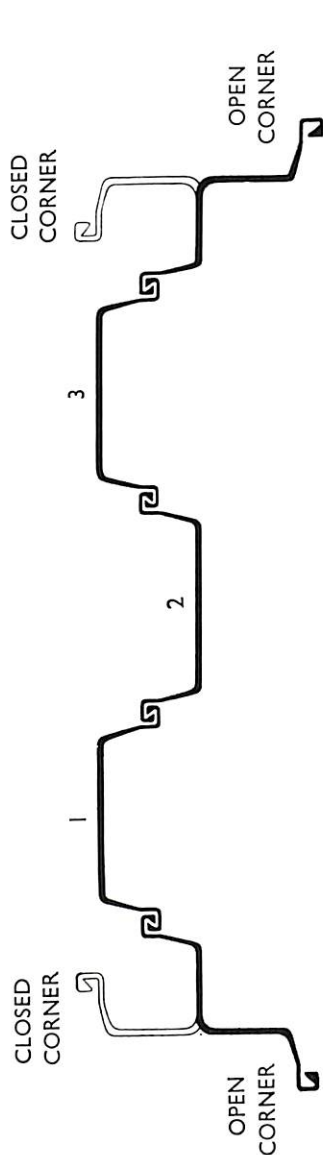
LARSEN STEEL SHEET PILING.

COMBINED SECTION 2/10 A.

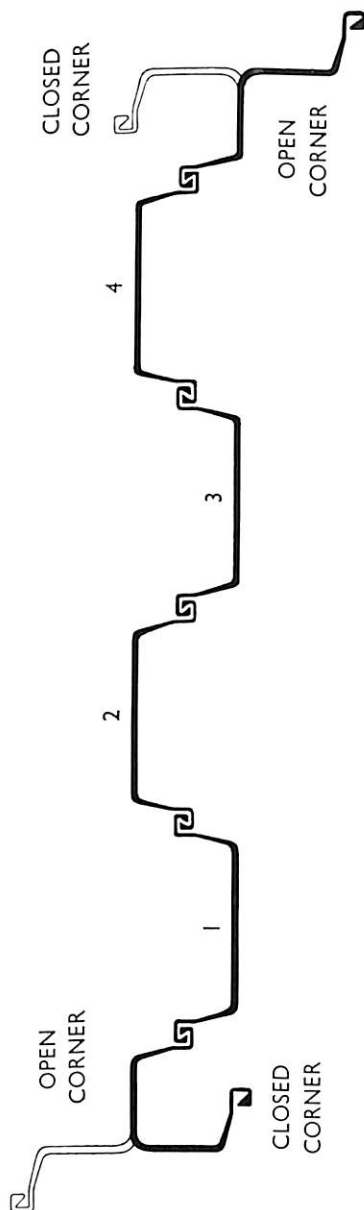
WEIGHT IN TONS WHEN INTERLOCKED.

Sq. Ft.	0	1	2	3	4	5	6	7	8	9
0	—	0-012	0-023	0-035	0-047	0-058	0-070	0-082	0-094	0-105
10	0-117	0-129	0-140	0-152	0-164	0-176	0-187	0-199	0-211	0-222
20	0-234	0-246	0-257	0-269	0-281	0-293	0-304	0-316	0-328	0-339
30	0-351	0-363	0-374	0-386	0-398	0-410	0-421	0-433	0-445	0-456
40	0-468	0-480	0-492	0-503	0-515	0-527	0-538	0-550	0-562	0-573
50	0-585	0-597	0-609	0-620	0-632	0-644	0-655	0-667	0-679	0-690
60	0-702	0-714	0-726	0-737	0-749	0-761	0-772	0-784	0-796	0-808
70	0-819	0-831	0-843	0-854	0-866	0-878	0-889	0-901	0-913	0-925
80	0-936	0-948	0-960	0-971	0-983	0-995	1-006	1-018	1-030	1-042
90	1-053	1-065	1-077	1-088	1-100	1-112	1-124	1-135	1-147	1-159
100	1-170	1-182	1-194	1-205	1-217	1-229	1-241	1-252	1-264	1-276
200	2-341	2-352	2-364	2-376	2-388	2-399	2-411	2-423	2-434	2-446
300	3-511	3-523	3-535	3-546	3-558	3-570	3-581	3-593	3-605	3-616
400	4-682	4-693	4-705	4-717	4-728	4-740	4-752	4-763	4-775	4-787
500	5-852	5-864	5-875	5-887	5-899	5-910	5-922	5-934	5-946	5-957
600	7-022	7-034	7-046	7-057	7-069	7-081	7-093	7-104	7-116	7-128
700	8-193	8-204	8-216	8-228	8-240	8-251	8-263	8-275	8-286	8-298
800	9-363	9-375	9-387	9-398	9-410	9-422	9-433	9-445	9-457	9-468
900	10-534	10-545	10-557	10-569	10-580	10-592	10-604	10-615	10-627	10-639
1000	11-704	11-716	11-727	11-739	11-751	11-762	11-774	11-786	11-798	11-809

ARRANGEMENT OF LARSEN CORNER PILES.

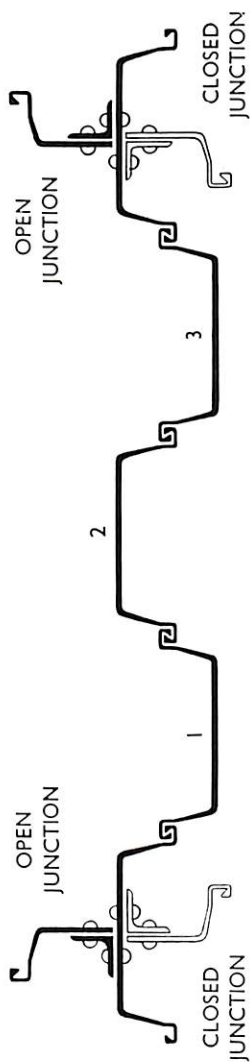


ODD NUMBER OF PLAIN PILES.

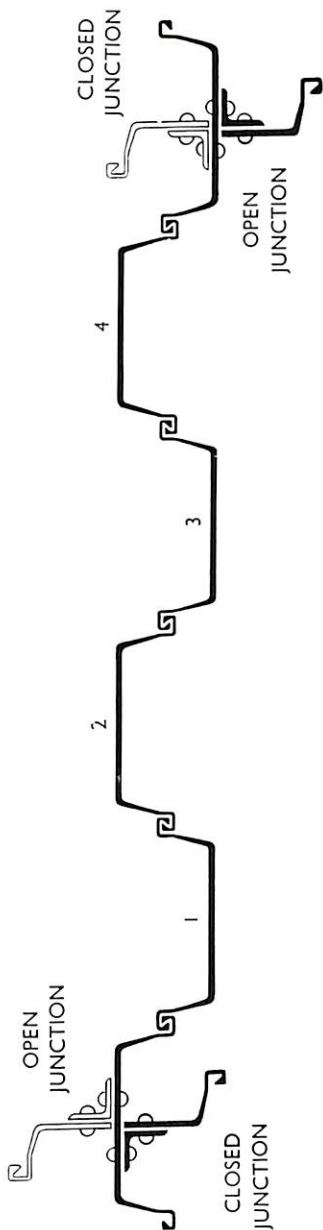


EVEN NUMBER OF PLAIN PILES.

ARRANGEMENT OF LARSEN JUNCTION PILES.



ODD NUMBER OF PLAIN PILES.



EVEN NUMBER OF PLAIN PILES.

LARSSEN CORNER AND JUNCTION PILES

GENERAL NOTES

CORNER PILES.

Standard Larssen Corner Piles are of three main types:—

Type (a) Bent on centre line of pile.

Type (b) Cut longitudinally and the two portions riveted to an angle or bent plate. Generally the cut is made down the centre of the pile so that one complete pile is used per riveted corner, but in the case of closed corners for pile 6, the cuts are made to suit the dimensions shown for 90° corner piles and more than one pile is needed per corner.

Type (c) Cut longitudinally, bent, and the two portions riveted together (Type 5A). Generally this type is made of one pile cut down the centre, but in the case of pile 4A more than one pile is needed per corner where the required angle is between 70° and 90°.

JUNCTION PILES.

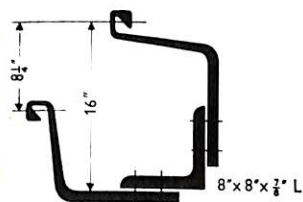
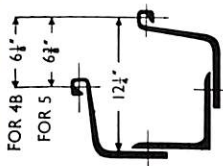
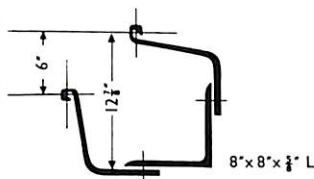
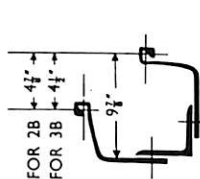
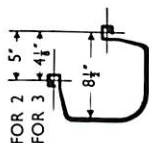
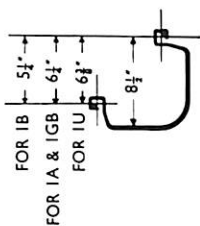
Standard Larssen Junction Piles normally consist of an ordinary pile with a half pile secured to its web by means of an angle riveted along the centre of the web of the whole pile.

In the case of Types 1 and 1A for piles 4A and 6 it is necessary to use two piles per junction as shown in order that the two lines of piling clear each other.

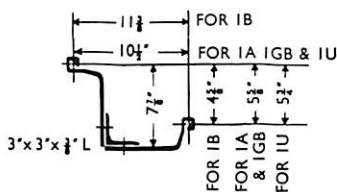
SPECIAL CORNERS AND JUNCTIONS to particular dimensions can be supplied if necessary.

LARSEN STEEL SHEET PILING.

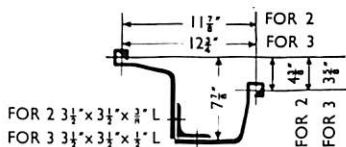
CLOSED CORNERS



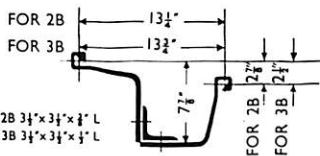
REVERSED CORNERS TYPE 4 (4A OPPOSITE HAND)



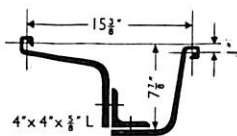
SECTIONS IA IB IGB & IU



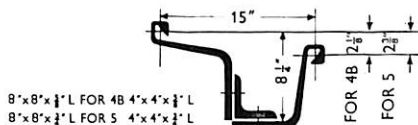
SECTIONS 2 & 3



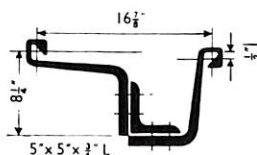
SECTIONS 2B & 3B



SECTION 4A



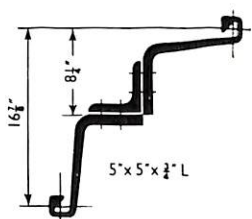
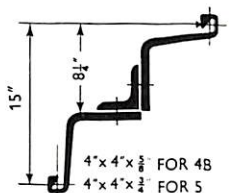
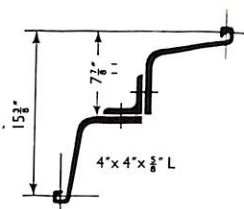
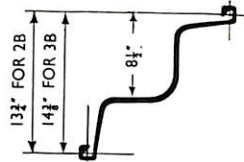
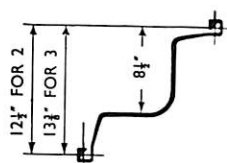
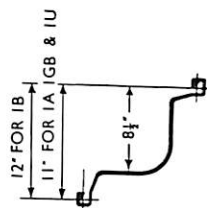
SECTIONS 4B & 5



SECTION 6

90° CORNER PILES

OPEN CORNERS



ESTIMATES
AND ORDERS

COFFERDAMS

RETAINING
WALLS

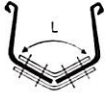
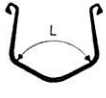
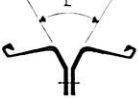
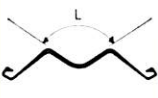
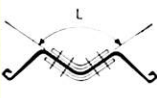
BEARING
PILES

FORMULAE
AND TABLES

INDEX

LARSEN STEEL SHEET PILING

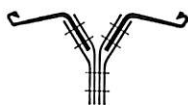
OBTUSE & ACUTE CORNER PILES

No.	TYPE 7	TYPE 8	TYPE 5A	TYPE 8A	TYPE 7A	No.
						
1A	—	Min. L 60°	Max. L 29°	Min. L 30°	—	1A
1B	—	Min. L 80°	Max. L 29°	Min. L 30°	—	1B
1GB	—	Min. L 60°	Max. L 29°	Min. L 30°	—	1GB
1U	—	Min. L 60°	Max. L 29°	Min. L 30°	—	1U
2	—	Min. L 80°	Max. L 29°	Min. L 30°	—	2
2B	—	Min. L 100°	Max. L 29°	Min. L 30°	—	2B
3	—	Min. L 91°	Max. L 89°	Min. L 91°	—	3
3B	—	Min. L 100°	Max. L 89°	Min. L 91°	—	3B
4A	L 115° to 134° Joint Plates 2- $\frac{3}{8}$ " Thick	Min. L 135°	Max. L 90°	Min. L 135°	L 91° to 134° Joint Plates 2- $\frac{3}{8}$ " Thick	4A
4B	L 110° to 134° Joint Plates 2- $\frac{3}{8}$ " Thick	Min. L 135°	Max. L 90°	Min. L 135°	L 91° to 134° Joint Plates 2- $\frac{3}{8}$ " Thick	4B
5	L 110° to 159° Joint Plates 2- $\frac{1}{2}$ " Thick	Min. L 160°	Max. L 40°	Min. L 160°	L 80° to 159° Joint Plates 2- $\frac{1}{2}$ " Thick	5
6	L 125° to 159° Joint Plates 2- $\frac{1}{2}$ " Thick	Min. L 160°	Max. L 40°	Min. L 160°	L 80° to 159° Joint Plates 2- $\frac{1}{2}$ " Thick	6

5 FOR LARSEN Nos. 5 & 6 WITH ANGLE L 41° TO 79° 5

&

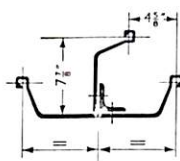
6 Type 5 Corner Joint Plates $\frac{1}{2}$ " Thick 6



LARSEN STEEL SHEET PILING.

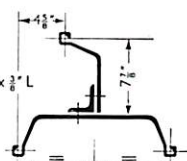
JUNCTION PILES

TYPE 1
(1A OPPOSITE HAND)

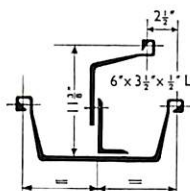


SECTION 1B

TYPE 3
(3A OPPOSITE HAND)

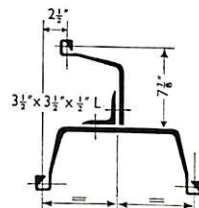


TYPE 1
(1A OPPOSITE HAND)



SECTION 3B

TYPE 3
(3A OPPOSITE HAND)



ESTIMATES
AND ORDERS

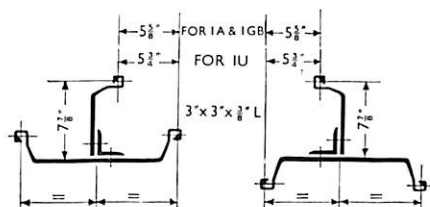
COFFERDAMS

RETAINING
WALLS

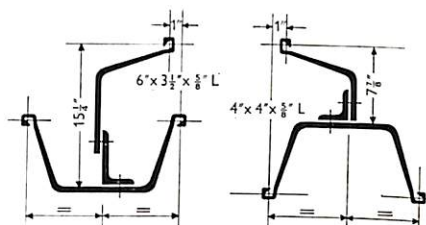
BEARING
PILES

FORMULAE
AND TABLES

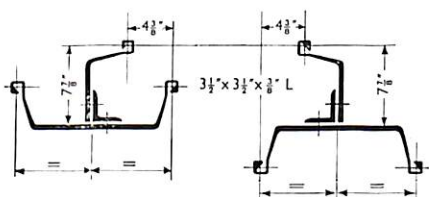
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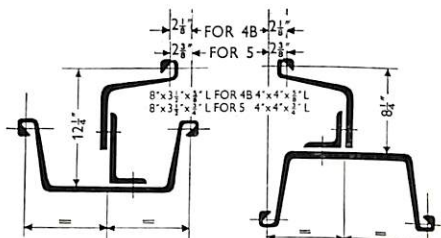
SECTIONS 1A 1GB & 1U



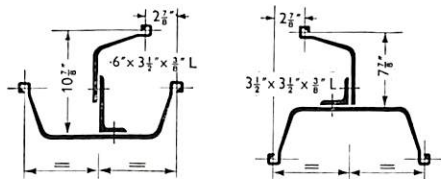
SECTION 4A



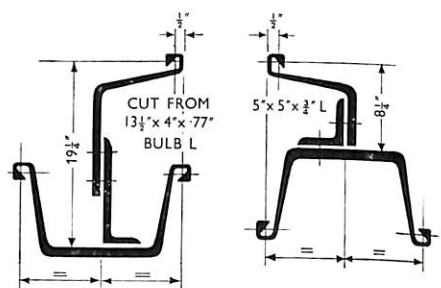
SECTION 2



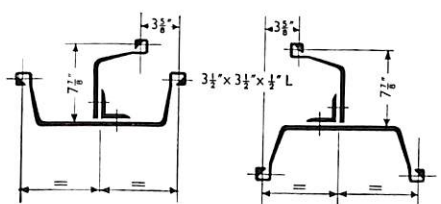
SECTIONS 4B & 5



SECTION 2B



SECTION 6



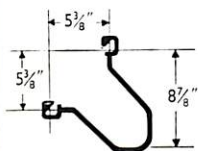
SECTION 3

LARSEN STEEL SHEET PILING

SECTION 10A

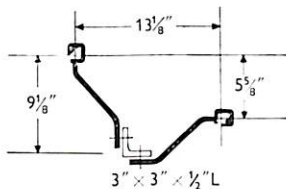
90° CORNER PILES

CLOSED CORNER

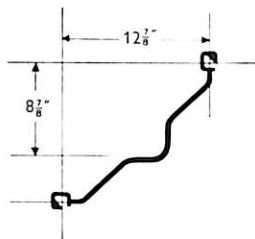


REVERSED CORNERS

TYPE 4 (4A OPPOSITE HAND)



OPEN CORNER



OBTUSE & ACUTE CORNER PILES

TYPE 8



TYPE 5A

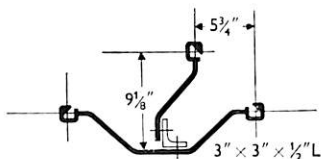


TYPE 8A

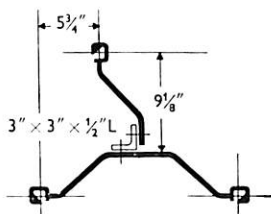


JUNCTION PILES

TYPE 1 (1A OPPOSITE HAND)



TYPE 3 (3A OPPOSITE HAND)



WEIGHTS OF STANDARD 90° CORNERS AND JUNCTIONS

Section No.	Size of Angle in inches				Dia- meter of Rivets in inches	Weight in lbs. per linear foot				
	Closed Corners	Reversed Corners	Open Corners	Junctions 3 & 3 A		Junctions 1 & 1 A	Closed Corners	Reversed Corners	Open Corners	Junctions 3 & 3 A
1 A	—	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	22-6	30-7	22-6	42-0	42-0
1 B	—	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	24-05	32-2	24-05	44-2	44-2
1 G B	—	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	24-3	32-4	24-3	44-6	44-6
1 U	—	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	28-5	36-6	28-5	50-9	50-9
2	—	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	32-79	42-2	32-79	58-6	58-6
2 B	5 × 5 × 5	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	44-6	40-8	31-38	56-5	59-6
3	—	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	41-66	53-6	41-66	74-5	74-5
3 B	5 × 5 × 5	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	58-8	53-7	41-7	74-5	78-8
4 A	8 × 8 × 8	4 × 4 × 4	—	4 × 4 × 4	4 × 4 × 4	83-9	66-9	66-9	91-8	104-2
4 B	8 × 8 × 8	4 × 4 × 4	—	4 × 4 × 4	4 × 4 × 4	91-0	73-9	73-9	102-3	109-8
5	8 × 8 × 8	4 × 4 × 4	—	4 × 4 × 4	4 × 4 × 4	107-6	87-2	87-2	120-8	129-7
6	8 × 8 × 8	5 × 5 × 5	—	5 × 5 × 5	5 × 5 × 5	160-3	107-7	107-7	148-6	180-0
10 A	—	3 × 3 × 3	—	3 × 3 × 3	3 × 3 × 3	40-4	50-7	40-4	70-9	70-9

NOTE: Where no "size of angle" is given the corner is a bent corner.

The weight given for Section 6 closed corner covers for the nett weight only of the part piles used in this corner.

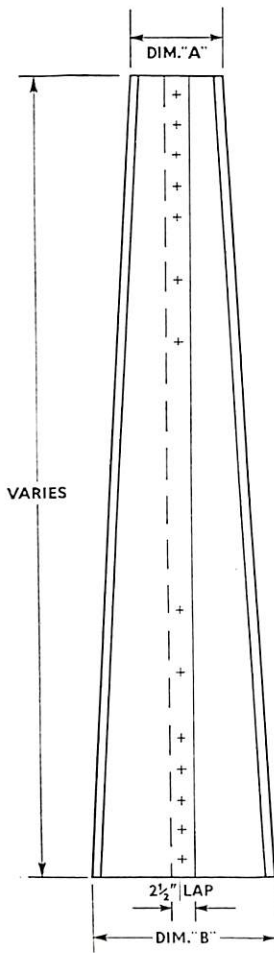
The weights given in column "Junctions 1 & 1 A" for Section 4 A & 6 cover for the nett weight only of the part piles used in these junctions.

The diameter of rivets shown for Section 6 is applicable only where one row is used; where two rows are used the rivets should be $\frac{7}{8}$ " diameter.

The accepted standard rivet pitch for all types of fabricated piles is 6", except for four 3" pitches at the top and five 3" pitches at the bottom commencing 1 $\frac{1}{4}$ " from the ends.

If it is necessary the rivets at the top can be countersunk to clear the leg guides of certain types of pile hammers and this requirement should be specified accordingly.

TAPERED PILES.



When a long stretch of piling is being driven and, due to unusual site conditions, an uneven creep has occurred so that the piles are slightly out of plumb, the introduction of one or more tapered piles gives the required correction.

Tapered piles can be supplied to any required dimensions which are not less than Dimension A, or more than Dimension B given for the Standard Tapered Pile in the table below.

The Standard Tapered Pile is manufactured to give the maximum slope that can be achieved without the introduction of a tapered jointing plate. (Note: For Section 10A it is necessary to introduce a tapered jointing plate).

DIMENSIONS—STANDARD TAPERED PILES

Section	Dimension A	Dimension B	Rivets-Dia.
1 A, 1 B, 1 GB, 1 U, 2, 2 B, 3, 3 B and 4 A ...	$8\frac{3}{8}"$	$17\frac{7}{8}"$	$\frac{3}{4}"$
4 B, 5 and 6 ...	$9\frac{3}{16}"$	$18\frac{1}{16}"$	$\frac{7}{8}"$

The pitch of rivets is in accordance with the notes regarding rivet pitches for all fabricated piles as shown on page 43.

FISHPLATES.

Whilst Larssen Piling can be rolled in lengths up to about 100 ft., handling facilities do not always permit the use of such long lengths. In these cases and where it is necessary to increase the pile length during driving, fishplated joints can be used.

Particulars of standard fishplated joints for Larssen sheet piles and Larssen Box Piles are available on application.

SLUICE GATES.

Hand operated sluice gates are available for use in Larssen Steel Sheet Walls.

These are of two types, either handwheel or ratchet lever operated, details of which will be forwarded on request.

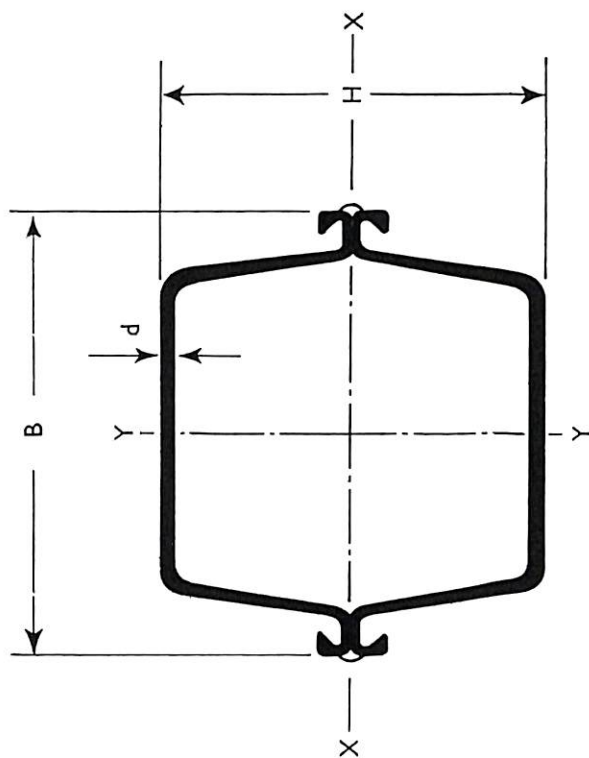
UNDER WATER—CUTTING AND WELDING.

Larssen piling can be comparatively easily cut or electrically welded under water, a process which in many cases is preferable to fishplating.

A number of firms specialise in this class of work and are prepared either to hire the necessary equipment or provide an equipped diver to carry out the job.

In good conditions, given easy access in clear water with good visibility and in the absence of severe currents, piles can be cut or welded under water at any depth for which they are normally used, almost as quickly and easily as on the surface.

LARSEN BOX PILES.



WEIGHTS AND PROPERTIES OF LARSEN BOX PILES.

Section	B ins.	H ins.	d ins.	Weight lbs./ft.	Sectional Area sq. ins.		Least Radius of Gyration ins.	Approx. Peri- meter ins.	Moment of Inertia ins. ⁴		Section Modulus ins. ³	
					Steel only	Whole Pile			About xx	About yy	About xx	About yy
BP 1 A	17	6 $\frac{9}{16}$	0.28	45.20	13.30	92.4	2.50	44	83.3	435.9	25.4	51.3
*BP 1 B	17	8 $\frac{7}{16}$	0.28	48.11	14.15	120	2.99	48	126.5	462.4	30.1	54.4
BP 1 GB	17	6 $\frac{1}{2}$	0.32	48.60	14.28	96	2.52	44	92.9	471.2	28.1	59.8
BP 1 U	17	6 $\frac{1}{2}$	0.37	57.00	16.78	96	2.52	44	110.0	567.0	33.2	66.3
BP 2	17 $\frac{1}{4}$	9 $\frac{7}{16}$	0.40	65.58	19.28	133	3.57	49	245.5	619.3	52.0	71.8
BP 2 B	17 $\frac{5}{32}$	12 $\frac{3}{8}$	0.34	62.76	18.46	167	4.16	55	319.5	628.4	51.6	73.3
BP 3	17 $\frac{1}{4}$	11 $\frac{3}{8}$	0.56	83.32	24.50	158	4.35	52	463.5	715.0	81.5	82.9
BP 3 B	17 $\frac{1}{4}$	13 $\frac{1}{2}$	0.53	83.40	24.52	180	5.02	56	619.2	726.0	91.7	84.2
BP 4 A	17 $\frac{5}{32}$	16 $\frac{7}{8}$	0.62	99.48	29.26	219	5.42	63	1136.9	860.9	135.0	100.4
BP 4 B	18 $\frac{3}{8}$	15 $\frac{1}{2}$	0.61	113.50	33.36	222	5.74	61	1094.3	1141.2	141.2	126.8
BP 5	18 $\frac{3}{8}$	15 $\frac{1}{2}$	0.87	134.38	39.52	222	5.60	61	1395.0	1236.6	180.0	137.4
BP 6	18 $\frac{1}{4}$	19 $\frac{3}{4}$	0.87	163.68	48.14	278	5.81	82	2542.3	1623.2	257.3	177.7

* Not yet available.

LARSSEN BOX PILES.

CONSTRUCTION. Larssen box piles are constructed by welding two ordinary Larssen sheet piles at suitable intervals along the interlocks.

Box piles can be constructed from any of the sections but those from No. 2 upwards are the ones in most common use.

CARRYING CAPACITY. In comparison with timber or concrete piles, provided that the ground is capable of developing a correspondingly high bearing resistance, Larssen box piles have a very large carrying capacity.

DRIVING. In general practice, Larssen box piles are driven open ended. Suitable shoes can be fitted either to pierce a harder stratum, or to develop the necessary bearing resistance.

Larssen box piles can be driven into very compact ground or soft rock and through, or into, hard strata without risk of damage. Soil displacement, particularly undesirable where soft clays are concerned, is normally entirely eliminated when open-end driving is employed.

Driving costs in relation to Larssen box piles can be expected to be appreciably lower than for timber or concrete piles as the required bearing capacity can usually be developed with

a pile hammer of moderate size. This frequently renders the use of a pile frame unnecessary and enables the hammer to be used suspended from a crane.

DURABILITY AND ADAPTABILITY.

Larssen box piles are more durable than timber piles. They can be easily introduced into a line of sheet piling if vertical loads require to be supported.

If it is necessary to make a site splice due to the use of a piling frame of moderate height or under special working conditions demanding driving in short lengths, Larssen box piles can be spliced with the minimum loss of time.

Larssen box piles stand up well to hard usage and do not require special care in handling. They are particularly suited to withstand handling and driving stresses when long lengths are being driven.

Larssen box piles are also very valuable in resisting surface bending stresses from horizontal forces. As columns, where a considerable length of pile is exposed above ground level, as for instance in dolphins, their rigidity and resistance to buckling are important advantages.

DURABILITY OF LARSSEN PILING STRUCTURES.

Deterioration of exposed steel structures in such parts as are inaccessible for painting and maintenance is inevitable in some degree.

During recent years many tests and investigations have been carried out all over the world to determine the resistance of Larssen piling to corrosion. Results of the series of 15-year tests carried out by the Sea Action Committee of the Institution of Civil Engineers, combined with the recorded results of examinations of piling structures which have been in use for periods up to 50 years and more, indicate that the useful life of a Larssen piling structure under normal conditions can be estimated on the basis of an average annual corrosion rate of 0.003 inches per year in sea water and 0.002 inches per year in fresh water.

The table on the adjoining page showing the effective life of the various Larssen sections is based on these figures which apply to steel to British Standard No. 15. The life of Larssen sections is of course considerably lengthened when the piles are rolled from either "Carfleco-Noncorr" copper-bearing steel or "Atlantes" high tensile rust-resisting steel.

EFFECTIVE LIFE OF LARSEN SECTIONS.

Section No.	Original Thickness in inches		Permissible loss in inches	Final Thickness in inches		Effective Life in years	
	Web	Legs		Web	Legs	Sea Water	Fresh Water
1A ...	0.28	0.23	0.13	0.15	0.10	45	65
1B ...	0.28	0.25	0.13	0.15	0.12	45	65
1GB ...	0.32	0.23	0.13	0.19	0.10	45	65
*1U ...	0.375	0.375	0.19	0.19	0.19	60	95
			<i>0.25</i>	<i>0.12</i>	<i>0.12</i>	<i>85</i>	<i>125</i>
2 ...	0.41	0.31	0.21	0.20	0.10	70	105
2B ...	0.34	0.28	0.13	0.21	0.15	45	65
3 ...	0.55	0.35	0.24	0.31	0.11	80	120
3B ...	0.53	0.35	0.24	0.29	0.11	80	120
4A ...	0.62	0.37	0.24	0.38	0.13	80	120
4B ...	0.63	0.43	0.30	0.33	0.13	100	150
5 ...	0.87	0.47	0.33	0.54	0.14	110	165
6 ...	0.87	0.55	0.33	0.54	0.22	110	165
*10A ...	0.50	0.50	0.25	0.25	0.25	85	125
			<i>0.38</i>	<i>0.12</i>	<i>0.12</i>	<i>125</i>	<i>190</i>
2/10A	0.41/ 0.50	0.31/ 0.50	0.21	0.20	0.10	70	105

* Sections No. 1U and 10A are provided with a uniform thickness and, when subjected to small stresses, it is permissible to increase the loss of thickness and the effective life to the figures shown in italics.

ESTIMATES AND ORDERS.

When ordering or estimating for Larssen piling the tables on pages 17-21 should be used to determine the number of piles required to cover a specified length.

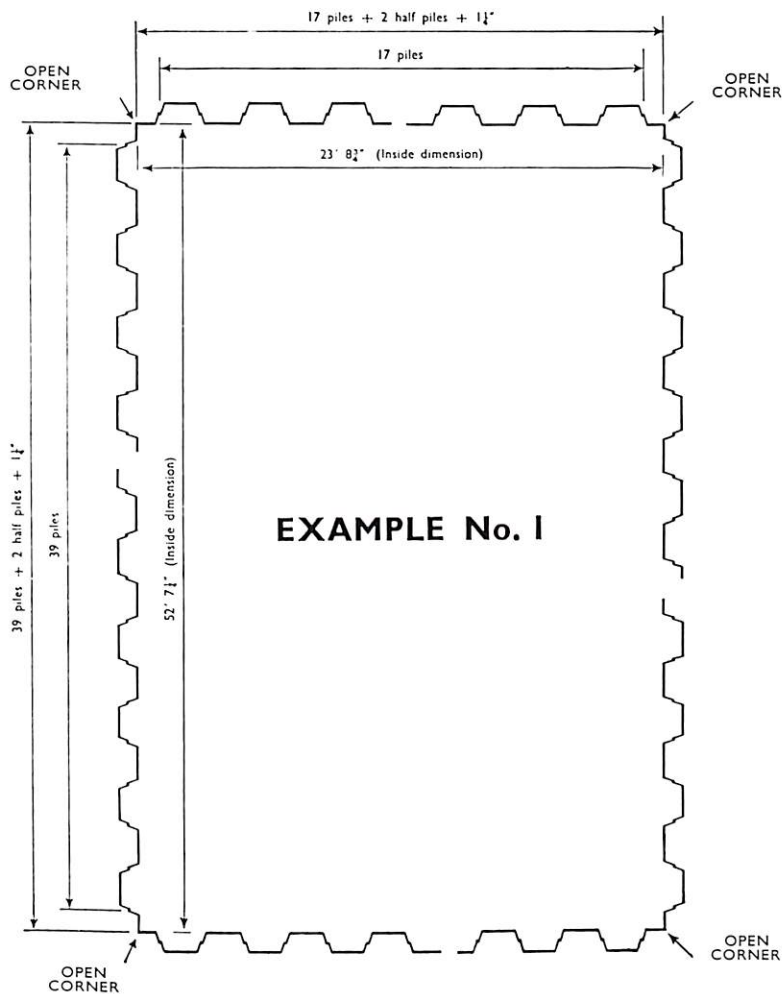
If corners or junctions are involved, reference should be made to pages 36 and 37 which show typical arrangements, to pages 38-42 which show the various types of standard corners and junctions and to the table of weights of standard 90° corners and junctions on page 43. Should difficulty be experienced in arriving at the dimensions required it is advisable to forward all information to the manufacturers so that drawings may be prepared. In cases of this nature the information to be sent should be as complete as possible and, when quoting the dimensions of a cofferdam, the sizes given will be taken to be the clear dimension between the piling unless otherwise specified (see examples on pages 53, 54 and 55).

The tables on pages 22-35 give the weight in tons per square foot applicable to the various sections of Larssen piling (one ton = 2,240 lbs.).

The maximum length of any pile is largely dependent on the depth of penetration, the type of ground into which it is to be driven and the conditions of construction.

Larssen Steel Sheet Piling—Estimates and Orders (continued)

Any project which appears to call for special treatment should be referred to the Manufacturers' technical staff, who will be pleased to advise.



EXAMPLE 1.

A cofferdam is required of minimum dimensions 23' 0" by 52' 0" the piles being 35' 0" long.
Using Larssen pile section 2.

SHORT SIDE.

The table on page 17 shows that 18 piles cover $23' 7\frac{1}{2}"$,
i.e. 17 piles and 2 half piles.

LONG SIDE.

The table on page 17 shows that 40 piles cover $52' 6"$,
i.e. 39 piles and 2 half piles.

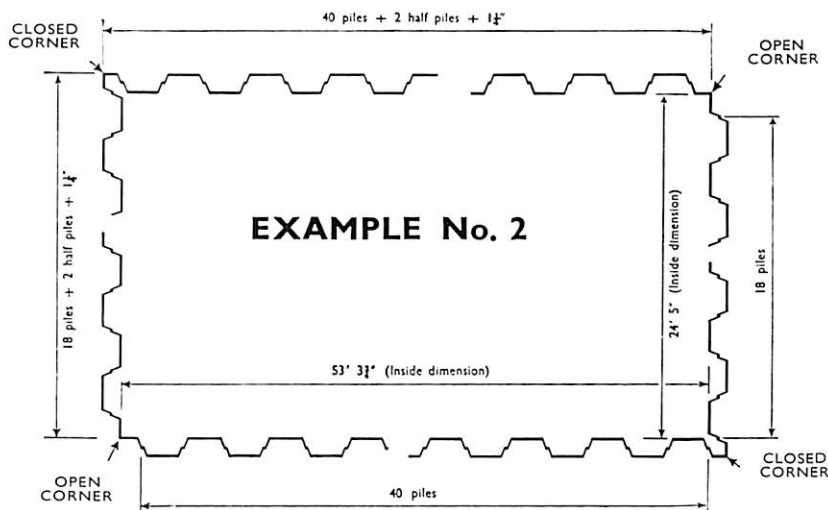
The number of plain piles in each side being "odd" all corners will be similar, *i.e.* Open Type which adds $1\frac{1}{4}"$ to the above lengths.

The inside dimensions are therefore $23' 8\frac{3}{4}" \times 52' 7\frac{1}{4}"$.

EXAMPLE 2.

A cofferdam similar to that in Example 1 but with minimum dimensions of $53' 0" \times 24' 0"$, using Larssen pile section No. 2 as before. From the table on page 17, 41 piles cover $53' 10"$, *i.e.* 40 piles and 2 half piles and 19 piles cover $24' 11\frac{1}{4}"$, *i.e.* 18 piles and 2 half piles.

The number of piles in each side being even, corners will be of two types, closed and open.



LONG SIDE.

40 piles (from table)	=	52'	6 1/4"
Closed Corner	=		8 7/8"
Open Corner	=		8 1/2"
		53'	11 5/8"
Less "h"	=		7 7/8"
		53'	3 3/4"

As a check:

40 piles	=	52'	6 1/4"
2 half piles	=	1'	3 3/4"
2 bends	=		1 1/4"
		53'	11 1/4"
Less (h-d)	=		7 1/2"
		53'	3 3/4"

SHORT SIDE.

18 piles (from table)	=	23'	7 1/2"
Closed Corner	=		8 7/8"
Open Corner	=		8 1/2"
		25'	0 7/8"
Less "h"	=		7 3/8"
		24'	5"

As a check:

18 piles	=	23'	7 1/2"
2 half piles	=	1'	3 3/4"
2 bends	=		1 1/4"
		25'	0 1/2"
Less (h-d)	=		7 1/2"
		24'	5"

The inside dimensions are therefore 53' 3 3/4" × 24' 5".

NOTE.

The values of “ h ” and “ d ” are given in the table “ Weights and Properties of Sections ” on page 15.

In cases where the required size calls for an even number of plain piles for one side and an odd number of plain piles for the other side, standard corners of Type 4 or 4A will be necessary for two corners and closed or open types for the other two corners.

CROSS WALLS.

Where a cross wall between two parallel lines of piling is required, standard junctions, as shown on page 40, can be used if the number of plain piles in the cross wall is odd, but if the number of plain piles in the cross wall is even, special eccentric junctions must be used so that the centre line of the cross wall piling is opposite the middle of the piles in the main wall.

Note that the piles in the main walls should be spaced to suit the conditions appertaining to the cross wall.

COFFERDAMS.

Symbols used in diagrams and formulae :

w = Weight of 1 cu. ft. of water: 64 lbs. sea water
62.4 lbs. fresh water

D = Total head of water

d = Depth of top waling to second waling in feet

M_w = Maximum Bending Moment in waling

Z_w = Section Modulus of waling

M_p = Maximum Bending Moment in piling

Z_p = Section Modulus of piling

P = Penetration into sub-soil

All calculations are based on one foot width of piling.

Larssen Piling is particularly suitable for the construction of cofferdams, as, due to the watertightness of the joints, little seepage occurs. A cofferdam may be formed with or without walings (or bracing). Walings should only be omitted when the cofferdam is shallow, as in this condition, the piling acts as a cantilever and the bending moment increases rapidly with the height. A deep cofferdam has its walls supported by several levels of walings. It is convenient to vary the spacing between waling levels so that the load at each level will be approximately equal and as the pressure increases towards the bottom of the cofferdam, it follows that the centres of the walings will decrease.

Larssen Steel Sheet Piling—Cofferdams (continued)

Piling is designed as a simply supported beam between waling (or bracing) levels and if these are arranged as previously suggested, the maximum bending moment will occur over the longest space which is between the top and second levels. To obtain the most economical piling section, calculations should be made on the loading between these waling levels.

$$\text{Load on pile (per foot width)} = \frac{wd^2}{2} \text{ lbs.}$$

$$\text{Maximum Bending Moment (Mp)} = \frac{wd^3}{2910} \text{ tons inches}$$

assuming triangular loading on a simply supported beam.

The diagram opposite indicates the levels at which walings should be placed to achieve approximately equal loading on each.

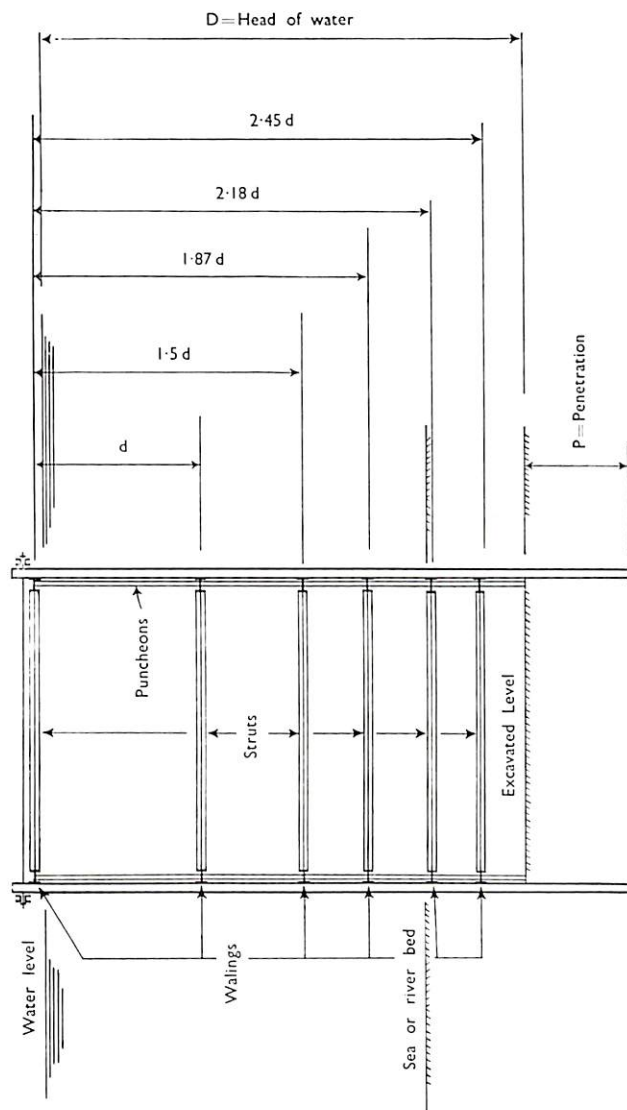
The top level of waling should always be placed at, or near to, the surface of the water.

As previously stated, piling is designed as a simply supported beam between waling levels. It follows that the maximum bending moment $(Mp) = fZp$. Assuming a safe stress on piling of $7\frac{1}{2}$ tons per square inch, the maximum length for d (1st to 2nd waling) $= \sqrt[3]{341Zp}$ for sea water.

For other stresses in piling, adjust the figure 341 in direct proportion to the stress chosen in place of the assumed stress of $7\frac{1}{2}$ tons per square inch.

The loading on walings is calculated on the assumption that the piling distributes pressure in the manner of simply supported beams between each level of waling. Struts should be placed at convenient points along the walings, the points chosen being

COFFERDAMS.



Larssen Steel Sheet Piling—Cofferdams (continued)

governed by the services required in the cofferdam and an economical length for waling.

Waling is designed as a simply supported beam, unless continuous over three or more spans. Stresses of 8 tons per square inch in bending and 5 tons per square inch in shear are recommended. Walings below the second level are all loaded to approximately the same amount, and the pressure per foot run on each equals $wd^2 \times .63$ lbs. (average).

Struts to support walings should be selected for their general stiffness. In a wide cofferdam it may be necessary to introduce vertical bracing to form a vertical girder in order that struts may receive intermediate support. Broad Flange Beams rolled by South Durham Steel and Iron Company Limited are excellent members for use both as struts and walings. Care should be taken in assessing the load in struts to note whether walings are jointed or continuous over the strut as in the latter case more load will be imposed.

Struts and walings should be adequately connected, preferably by means of bolts. The various levels of walings are kept in position either by tie rods suspended from the top level, or supported from ground level by puncheons. It is preferable that in large cofferdams, a system of tie rods through an independent set of external walings should be adopted and placed just above the top level of internal waling.

Larssen Steel Sheet Piling—Cofferdams (continued)

Diagonal bracing between various levels of waling is also necessary according to the size and location of the cofferdam.

The depth of penetration P , of the piling into the subsoil, should be great enough to allow an ample margin of safety against soil being forced up by external pressure into the working area. The passive resistance should be calculated from Bell's formula, and a margin of safety allowed.

As all large cofferdams have their own peculiar problems, it is advisable to seek the advice of the South Durham technical staff, the services of which are freely available at all times.

DESIGN OF COFFERDAMS.

The tables which follow on pages 63-67 have been prepared with the object of facilitating routine design work. The procedure for using the tables is outlined below.

- (i) Given the dimensions of the cofferdam, it is possible to ascertain the number of walings from Table 2, bearing in mind the services required for construction purposes.
- (ii) Space out the walings in accordance with Table 2, which will automatically fix the distance from the first waling at water level down to the second waling. The second and successive walings will all carry equal loads, for similar strut centres.
- (iii) The piling section can be determined from Table 1, corresponding to the depth from first to second waling but the choice of a suitable section may be influenced, especially in deep cofferdams, by the ability to handle the piles in one length.
- (iv) The bending moment corresponding to the depth of the second waling and various strut centres is given in Table 3, from which the correct size of waling, whether of steel or timber, can then be selected from Table 5.

Larssen Steel Sheet Piling—Cofferdams (continued)

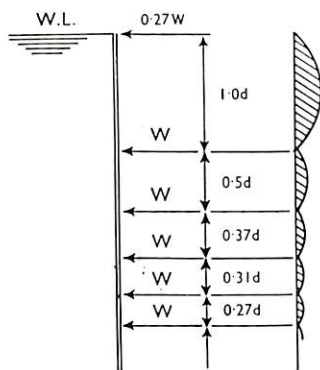
(v) If timber struts are desirable, these can be selected from Table 6, having previously determined from Table 4 the load on the struts corresponding to the depth of the second waling. Alternatively, steel struts may be used.

From the foregoing it is obvious that theoretically a variety of lay-outs is possible. Should there be any doubt as to the most practical and economical solution to any particular problem, advice and assistance can be obtained from the South Durham design staff on application.

NOTE TO BE READ IN CONNECTION WITH TABLES.

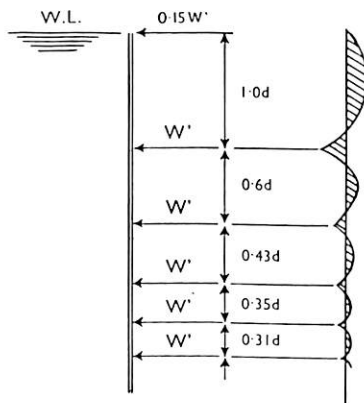
The first column in Table 2 gives the required spacing of walings in relation to "d" (distance from top waling at water level to 2nd waling) for equal loadings on each waling. The derived spacings assume that the piling is simply supported between the walings. Diagrams (A) and (B) are produced to show the difference between assuming simply supported and continuous piling.

DIAGRAM A



**B.M. Diagram
for simply supported
piling**

DIAGRAM B



**B.M. Diagram
for fully continuous
piling**

Larssen Steel Sheet Piling: COFFERDAMS.

**TABLE 1. MAXIMUM DEPTH FROM FIRST TO SECOND WALING
(TOP WALING POSITIONED AT WATER LEVEL).**

SECTION	1 A	1 B	1 GB	1 U	2	2 B	3	3 B	4 A	4 B	5	6	10 A
DEPTH	13' 0"	15' 0"	13' 6"	14' 6"	17' 0"	18' 6"	20' 0"	21' 0"	24' 6"	24' 0"	25' 0"	29' 0"	15' 6"

**TABLE 2. POSITION OF SECOND AND SUCCESSIVE WALINGS
(TOP WALING AT WATER LEVEL AND LOWER WALINGS SPACED TO CARRY EQUAL LOADS).**

d	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1-5 d	8' 0"	12' 0"	15' 0"	17' 6"	19' 6"	21' 6"	23' 3"	28' 0"	29' 9"
1-87 d	9' 0"	13' 6"	16' 9"	19' 6"	22' 0"	24' 3"	26' 0"	28' 0"	33' 0"
2-18 d	10' 0"	15' 0"	18' 9"	21' 9"	24' 6"	27' 0"	29' 0"	31' 3"	36' 3"
2-45 d	11' 0"	16' 6"	20' 6"	24' 0"	26' 3"	29' 6"	32' 3"	35' 0"	39' 9"
2-69 d	12' 0"	18' 0"	22' 6"	26' 3"	30' 6"	34' 3"	37' 6"	40' 9"	46' 3"
2-91 d	13' 0"	19' 6"	24' 3"	28' 3"	33' 0"	36' 9"	40' 3"	43' 6"	49' 6"
3-12 d	14' 0"	21' 0"	26' 3"	30' 6"	35' 0"	39' 3"	43' 0"	46' 6"	53' 9"
3-31 d	15' 0"	22' 6"	28' 0"	32' 9"	36' 9"	40' 3"	43' 6"	46' 9"	53' 0"
	16' 0"	24' 0"	30' 0"	35' 0"	39' 3"	43' 0"	46' 6"	50' 0"	56' 0"
	17' 0"	25' 6"	31' 9"	37' 0"	41' 6"	44' 0"	48' 6"	52' 3"	58' 3"
	18' 0"	27' 0"	33' 9"	39' 3"	44' 0"	46' 6"	51' 0"	55' 3"	61' 0"
	19' 0"	28' 6"	35' 6"	41' 6"	46' 6"	49' 0"	53' 9"	58' 3"	64' 0"
	20' 0"	30' 0"	37' 6"	43' 6"	49' 0"	51' 6"	56' 6"	62' 6"	68' 9"
	21' 0"	31' 6"	39' 3"	45' 9"	51' 6"	54' 0"	59' 0"	65' 6"	72' 9"

The above dimensions are based on a stress of $7\frac{1}{2}$ tons per sq. inch. For the other stresses the dimensions vary as the cube root of the stress chosen to the cube root of $7\frac{1}{2}$ tons per sq. inch.

Larsen Steel Sheet Piling: COFFERDAMS.

TABLE 3. BENDING MOMENT IN TONS INCHES, ON SECOND AND LOWER WALINGS
(TOP WALING AT WATER LEVEL AND LOWER WALINGS SPACED TO CARRY EQUAL LOADS).

Centres of Struts	Depth of Second Waling from Water Level														
	8' 0"	9' 0"	10' 0"	11' 0"	12' 0"	13' 0"	14' 0"	15' 0"	16' 0"	17' 0"	18' 0"	19' 0"	20' 0"	21' 0"	22' 0"
6' 0"	62	79	97	118	140	165	191	218	249	281	315	351	389	428	472
7' 0"	85	107	132	160	191	224	260	298	338	382	428	478	530	584	640
8' 0"	110	140	173	209	250	293	338	389	443	500	560	624	691	762	835
9' 0"	140	177	218	264	316	370	429	493	560	632	709	790	875	965	1065
10' 0"	172	219	270	327	390	456	528	608	692	780	876	975	1080		
11' 0"	210	264	327	396	470	551	640	736	835	944	1059				
12' 0"	248	315	389	472	560	657	763	875	997						
13' 0"	292	371	456	552	657	772	893	1026							
14' 0"	338	428	529	641	765	895	1037								
15' 0"	389	491	608	736	876	1026									

Table 3 is based on the walings being equally loaded at 0.63 wd² lbs. ft. and simply supported between struts. (The walings also transmit axial compression from end to end or side to side of the cofferdam).

Larssen Steel Sheet Piling: COFFERDAMS.

**TABLE 4. LOAD ON STRUTS CONNECTED TO SECOND AND LOWER WALINGS (IN TONS)
(TOP WALING AT WATER LEVEL AND LOWER WALINGS SPACED TO CARRY EQUAL LOADS).**

Centres of Struts	Depth of Second Waling from Water Level														
	8' 0"	9' 0"	10' 0"	11' 0"	12' 0"	13' 0"	14' 0"	15' 0"	16' 0"	17' 0"	18' 0"	19' 0"	20' 0"	21' 0"	22' 0"
6' 0"	6.9	8.8	10.8	13.1	15.6	18.3	21.2	24.3	27.7	31.2	35.0	39.0	43.2	47.6	52.4
7' 0"	8.1	10.2	12.6	15.2	18.2	21.3	24.7	28.4	32.2	36.4	40.8	45.5	50.4	55.6	61.0
8' 0"	9.2	11.7	14.4	17.4	20.8	24.4	28.2	32.4	36.9	41.6	46.6	52.0	57.6	63.5	69.6
9' 0"	10.4	13.1	16.2	19.6	23.4	27.4	31.8	36.5	41.5	46.8	52.5	58.5	64.8	71.5	78.4
10' 0"	11.5	14.6	18.0	21.8	26.0	30.4	35.2	40.5	46.1	52.0	58.4	65.0	72.0	79.5	87.2
11' 0"	12.7	16.0	19.8	24.0	28.5	33.4	38.8	44.6	50.6	57.2	64.2	71.5	79.2	87.5	
12' 0"	13.8	17.5	21.6	26.2	31.1	36.5	42.4	48.6	55.4	62.4	70.0	78.0	86.4		
13' 0"	15.0	19.0	23.4	28.3	33.7	39.6	45.8	52.6	60.0	67.6	76.0	84.5			
14' 0"	16.1	20.4	25.2	30.5	36.4	42.6	49.4	56.7	64.5	72.8	81.8				
15' 0"	17.3	21.8	27.0	32.7	38.9	45.6	53.0	60.8	69.1	78.0	87.5				

Table 4 is based on the struts transmitting the simply supported waling reaction.

Larssen Steel Sheet Piling: COFFERDAMS.

TABLE 5. STRENGTH OF WALINGS.

2 STEEL CHANNELS	Size in ins. of each channel	6" x 3" 12.41 lbs	6" x 3 1/2" 16.48 lbs	7" x 3 1/2" 18.28 lbs	8" x 3 1/2" 20.21 lbs	9" x 3 1/2" 22.27 lbs	10" x 3 1/2" 24.46 lbs	12" x 3 1/2" 26.37 lbs	12" x 4" 31.33 lbs	13" x 4" 33.18 lbs	15" x 4" 36.37 lbs	17" x 4" 44.34 lbs
	Section Modulus ins. ³	14.2	19.3	24.5	30.3	36.7	43.8	53.2	66.7	76.0	93.1	122.4
	Permissible B.M. in tons ins.	11.4	154	196	242	294	350	426	534	608	745	979
	Max. Shear in tons	15.0	16.8	21.0	25.6	30.6	36.0	45.5	48.0	52.0	61.5	81.6
STEEL I BEAMS	Size in ins.	8" x 4" 18 lbs.	9" x 4" 21 lbs.	10" x 4 1/2" 25 lbs.	10" x 5" 30 lbs.	10" x 6" 40 lbs.	12" x 6" 44 lbs.	16" x 6" 50 lbs.	16" x 8" 75 lbs.	12" x 12" 83 lbs.	14" x 12" 100 lbs.	16" x 12" 110 lbs.
	Section Modulus ins. ³	13.9	18.0	24.5	29.3	41.0	52.8	77.3	121.7	109.2	150.1	188.5
	Permissible B.M. in tons ins.	11.1	144	196	234	328	422	618	974	874	1201	1508
	Max. Shear in tons	11.2	13.5	15.0	18.0	18.0	24.0	32.0	38.4	28.2	38.4	44.0
TIMBER SECTION	Size in ins.	6" x 6"	9" x 6"	12" x 6"	9" x 9"	12" x 9"	10" x 10"	12" x 12"	14" x 14"	16" x 16"		
	Section Modulus ins. ³	36	54	72	121	162	167	288	456	684		
	Permissible B.M. in tons ins.	28	43	57	97	130	134	230	365	548		
	Maximum Span in ft.	5	5	5	5	5	5	6	7	8		

Table 5 is based on an extreme fibre stress in bending of 8 tons per sq. inch for steel and 1,800 lbs. per sq. inch for timber. The shear values are calculated on the gross web section at 5 tons per sq. inch in the case of steel and the maximum spans shown for timber walings ensures that the shear stresses are within safe limits when the waling is stressed to 1,800 lbs. per sq. inch.

Larssen Steel Sheet Piling: COFFERDAMS.

TABLE 6. SAFE LOAD ON TIMBER STRUTS, IN TONS.
ENDS CUT SQUARE. LOAD CONCENTRIC AND AT RIGHT ANGLES TO STRUT

Length in feet	Size in inches														
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
6	7.4	13.8	21.3	29.9	39.8	50.7	63.5	77.1	92.3	109.0	126.0	145.0	164.0	183.0	202.0
8	5.0	10.9	18.5	27.6	37.9	49.1	61.8	75.6	90.4	106.0	124.0	143.0	162.0	181.0	200.0
10	3.3	7.8	14.8	24.0	34.5	46.3	59.1	73.1	88.5	105.0	122.0	141.0	160.0	179.0	198.0
12	2.3	5.7	11.3	19.4	29.9	41.9	55.1	70.0	85.3	102.0	119.0	138.0	157.0	176.0	195.0
14	1.8	4.2	8.6	15.4	24.8	36.6	49.8	64.2	80.4	97.5	116.0	135.0	154.0	173.0	192.0
16	1.3	3.3	6.7	12.2	20.2	30.6	43.8	58.2	74.0	91.7	111.0	130.0	149.0	168.0	187.0
18	1.0	2.6	5.3	9.8	16.4	25.5	36.9	51.3	67.0	85.0	104.0	124.0	144.0	164.0	184.0
20	—	2.1	4.4	8.1	13.5	21.2	31.5	44.3	59.5	76.7	95.5	116.0	136.0	156.0	176.0
22	—	1.7	3.7	6.7	11.3	17.8	26.6	38.0	51.8	68.2	86.5	107.0	127.0	147.0	167.0
24	—	—	3.1	5.7	9.5	15.1	22.8	32.7	45.4	60.2	77.6	98.5	119.0	139.0	159.0
26	—	—	2.6	4.9	8.3	13.0	19.6	28.2	39.6	53.1	69.0	87.8	108.0	128.0	148.0
28	—	—	2.3	4.2	7.2	11.3	17.0	24.6	34.4	46.4	61.8	79.0	99.0	119.0	139.0
30	—	—	—	3.6	6.2	10.0	15.0	21.7	30.3	44.0	54.5	70.8	90.8	110.8	130.8
32	—	—	—	3.2	5.5	8.8	13.3	19.0	26.7	37.0	48.7	63.1	82.1	102.1	122.1
34	—	—	—	—	4.8	7.8	11.9	17.0	24.0	32.5	43.3	56.9	75.9	94.9	113.9
36	—	—	—	—	4.3	7.0	10.7	15.4	21.5	29.2	39.0	51.1	67.1	84.1	101.1
38	—	—	—	—	—	6.0	9.6	14.0	19.5	26.4	35.3	46.1	59.1	75.1	91.1
40	—	—	—	—	—	5.6	8.6	12.7	17.8	24.0	32.5	41.8	53.8	68.8	83.8
42	—	—	—	—	—	5.1	7.8	11.5	16.2	22.1	29.3	38.4	49.4	62.4	77.4
44	—	—	—	—	—	—	7.0	10.5	14.8	20.4	26.9	35.2	45.2	57.2	70.2
46	—	—	—	—	—	—	6.5	9.5	13.5	18.5	24.8	32.2	41.2	51.2	63.2
48	—	—	—	—	—	—	—	8.7	12.4	17.1	23.0	29.9	38.9	48.9	58.9
50	—	—	—	—	—	—	—	—	11.4	16.0	21.3	27.8	35.8	45.8	55.8

The above safe loads are calculated on a stress of 1,500 lbs. per sq. inch parallel to the grain and are, therefore, suitable for new Douglas Fir or Pitch Pine of good quality. For lower grades of timber, the safe loads will be proportionately reduced. For rectangular struts, if x and y be the long and short sides, the safe load = (tabular load corresponding to y) $\times x/y$. For round struts, take diameter as side and multiply tabular load by 0.7.

Triple circular cofferdam of Larssen No. 2 Section, forming base for oil storage tank installation for the Regent Oil Co. Ltd. at Invicta Wharf, Point Pleasant, London, S.W.18. Engineers: The Engineering Department, Regent Oil Co. Ltd. Main Contractors: Shellabear, Price, Contractors, Ltd. Piling Sub-contractors: G. Tate & Son, Ltd.



CELLULAR CONSTRUCTION.

The flexibility in the joints of Larssen Piling permits of a slight deviation from the straight line, without provision of individual bent corner piles. It therefore follows that if an equal deviation is made at each joint, a circle will be formed. It is necessary to use an even number of piles to make a complete circle and if a deviation of 9° (Note: This has been proved from experience to be a practical angle of deviation) is allowed at each joint a total of 40 piles will be required per circle.

Larssen Steel Sheet Piling—Cellular Construction (continued)

The diameter of the circle is entirely dependent on the section of pile selected and, working to the recommended angle of deviation of 9° , the following table gives the approximate diameter for each section of Larssen pile.

Section of Larssen Piling	Approximate diameter of circle	Approx. (max.) Driving Length
1 A, 1 B, 1 GB, 1 U	16' 9"	20' 0"
2, 2 B, 3, 3 B	16' 9"	30' 0"
4 A	16' 9"	50' 0"
4 B, 5	17' 7"	50' 0"
6	17' 7"	50' 0"
10 A	18' 10"	30' 0"

The above table is intended only as a guide as the deviation will depend upon several other factors such as type of ground, length of piles and penetration required. The last column of the table is intended as an indication of the approximate length of pile recommended for use in each case.

Smaller diameters can be obtained if individual bent corners are introduced.

On the site it is necessary to pitch, and complete the whole circle before driving. Driving is then carried out in stages, *i.e.* each pile is partially driven as the hammer works its way several times around the circumference.

RETAINING WALLS.

Retaining walls of Larssen piling can generally be grouped under two headings:

- (1) Retaining walls without anchorage.
- (2) Retaining walls with anchorage.

In retaining walls without anchorage the piling acts as a cantilever and the stability of the wall depends on the development of the passive pressure at the foot of the wall due to penetration, being able to resist the pressure exerted by the retained earth. This kind of retaining wall is only suitable when the height of earth to be retained is small.

In retaining walls with tied anchorage the piling acts as a propped cantilever in the case of a fixed earth support, and as a simple beam in the case of a free earth support. The anchored retaining wall has the advantage of requiring less penetration than a cantilever wall. The fixed earth condition is preferable in anchored walls and this will be described in the section on Anchored Sheet Piling.

EARTH PRESSURES.

The earth pressure acting on a retaining wall is commonly calculated from Bell's formula, which neglects friction between the earth and the wall. Bell's theory is based upon the angle of internal friction and cohesion of the material. In all cases a 1' 0" length of wall is considered.

Larssen Steel Sheet Piling—Retaining Walls (continued)

The active earth pressure from the retained earth

$$= p_a = w.h.\tan^2 \left(45 - \frac{\phi}{2} \right) - 2.C.\tan \left(45 - \frac{\phi}{2} \right)$$

The passive earth pressure at the foot of the wall

$$= p_p = w.h.\tan^2 \left(45 + \frac{\phi}{2} \right) + 2.C.\tan \left(45 + \frac{\phi}{2} \right)$$

Where p_a and p_p = intensity of earth pressure in lbs. per square foot

w = density of earth in lbs. per cubic foot

ϕ = angle of internal friction in degrees

h = height in feet under consideration

C = cohesion in lbs. per square foot.

The terms $\tan^2 \left(45 - \frac{\phi}{2} \right)$ and $\tan^2 \left(45 + \frac{\phi}{2} \right)$ can be more

conveniently referred to as k_a , coefficient of active pressure and k_p , coefficient of passive pressure respectively.

Hence— $p_a = w.h.k_a - 2.C \sqrt{k_a}$ and $p_p = w.h.k_p + 2.C \sqrt{k_p}$

It is sufficiently accurate to assume hydrostatic variation in these pressures, although this kind of distribution is not quite true for a flexible sheet pile wall.

SUPERIMPOSED LOAD.

The lateral thrust due to a uniformly distributed superimposed load (W_s) behind a vertical wall is given by:

$$p_a = w.h_e.k_a - 2.C \sqrt{k_a} \text{ where } h_e = \frac{W_s}{w}$$

PROPERTIES OF VARIOUS SOILS

Material	Density w lbs./ft. ³	Angle of Internal Friction ϕ	Cohesion lb./ft. ²
Gravel and Sand ...	110	30—35°	0
Compact Earth (Dry) ...	90	35—40°	0
" " (Damp) ...	100	40—45°	0
Silt " ...	110	10—30°	Under 375
Clay—Soft ...	110	0	375—750
Firm ...	110	0	750—1,500
Stiff ...	120	0	1,500—3,000
Sandy Clay ...	110	5—15°	1,000
Peat (Damp) ...	70	20—40°	0

TABLE OF COEFFICIENTS.

Angle			k_a	k_p
5°	...	...	0.840	1.19
10°	...	...	0.704	1.42
15°	...	...	0.589	1.70
20°	...	...	0.490	2.04
25°	...	...	0.406	2.46
30°	...	...	0.333	3.00
35°	...	...	0.271	3.69
40°	...	...	0.217	4.60
45°	...	...	0.172	5.83

EFFECT OF WALL FRICTION.

As previously mentioned, Bell's formula neglects the effect of the wall friction. The frictional effects of the earth acting upon the wall depend upon the dryness of the soil and the smoothness of the wall. Usually, when calculating the active pressure, wall friction can be ignored without risk of serious error. However, the effect of wall friction tends to increase very considerably the resistance of the passive forces and therefore it is generally permissible to increase the passive pressures as derived by Bell's formula. This increase should be from 1.5 to 2.0 times the amount previously stated, provided the angle of internal friction " ϕ " is not less than 25°. When dealing with waterlogged ground, or soils having an angle of internal friction less than 25° the increased values of Bell's formula should not be used. Where retained earth is liable to become fully waterlogged or buoyant the sheet piling should be designed to resist the full hydrostatic pressure in addition to the earth pressure.

Larssen Steel Sheet Piling—Retaining Walls (continued)

The active earth pressure for submerged earth is given by the following expression:

$$p_a = \left[w - \left(\frac{100 - v}{100} \right) 62.5 \right] k_a h$$

where v = percentage of voids in the soil
other terms having the usual meaning.

In the absence of more definite information, “ v ” may be taken as 40%.

DESIGN OF SHEET PILING RETAINING WALLS.

(1) Cantilever Sheet Piling.

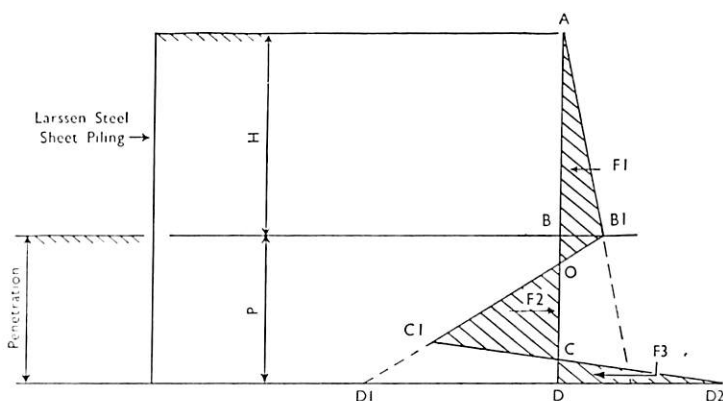


FIGURE 1. Simplified Pressure Diagram

B.O.B1. represents the active pressure at B.

D.D1. represents the net passive pressure at D.

The stability of the cantilever wall depends upon the resistance of the earth into which it is driven. Fig. 1 indicates the forces acting on the wall.

These are

F1 (representing area A.O.B1.) the total net active pressure on the wall.

F2 (representing area O.C.C1.) the total net passive pressure on the wall.

F3 (representing area C.D.D2.) the total net passive pressure required to fix the toe of the wall

Larssen Steel Sheet Piling—Retaining Walls (continued)

$$B.B1. = wHk_a - 2.C\sqrt{k_a}$$

$$D.D1. = [wPk_p + 2.C\sqrt{k_p}] - [w(H + P)k_a - 2.C\sqrt{k_a}]$$

$$D.D2. = [w(P + H)k_p + 2.C\sqrt{k_p}] - [w.P.k_a - 2.C\sqrt{k_a}]$$

The k_p values in the expressions for D.D1 and D.D2 may be multiplied by a factor “ K ” having a value of 1.5 to 2.0, according to the angle of internal friction. The point O occurs where the passive resistance on the left of the wall is equal to the active earth pressure on the right of the wall and is best determined by plotting the nett pressure diagram.

Forces F1, F2 and F3 are assumed as acting at the centres of pressure of the areas they represent. Moments of the active and passive pressures must balance about the toe of the wall and forces F1, F2 and F3 must also balance. To satisfy these conditions, the penetration is best determined by trial and error.

The bending moment in the piling can be found by taking moments about the level of zero shear of that part of the pressure diagram above this level. Fig. 2 and the adjacent table set out a simplified procedure when dealing with uniform cohesionless soils.

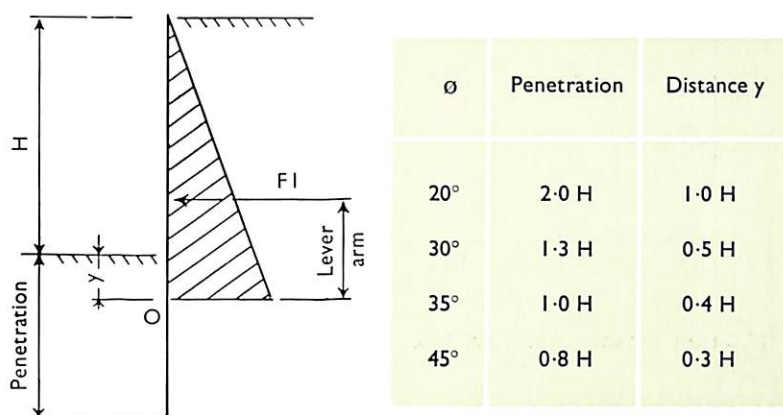


FIGURE 2. Triangular Distribution of Active Pressure

The pressure diagrams shown here assume uniform soils. When these become non-uniform, e.g. several strata of soils with different properties, the same basic principles apply but since the pressure diagrams will no longer be a series of uniform triangles, the problem becomes more complex. It should be appreciated that this is usually the case in practice.

(2) Anchored Sheet Piling (Fixed Earth Support)

Anchored sheet piling does not depend entirely on the development of large passive pressures for stability as in the case of cantilever piling. Consequently some reduction in penetration is possible, or for a given piling section the height of retained earth could be increased.

Larssen Steel Sheet Piling—Retaining Walls (continued)

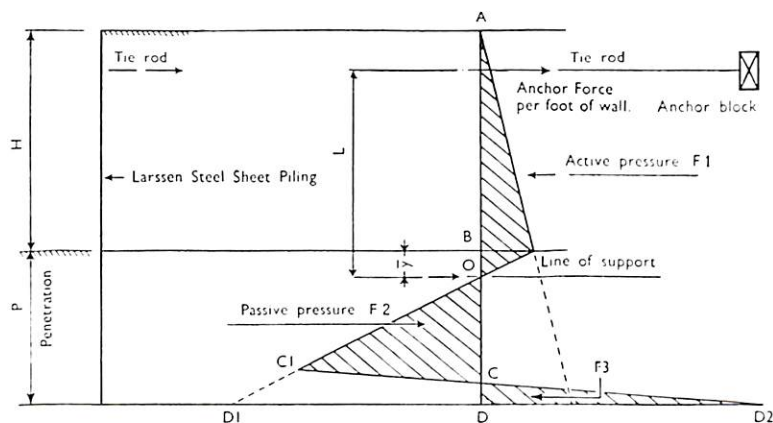


FIGURE 3. Simplified Pressure Diagram for Fixed Earth Support.

It is usual when designing anchored sheet piling to assume no movement of the anchor block and hence the piling can be designed as an "equivalent beam" of span L , supporting the load due to the active earth pressure.

The earth pressures are plotted as shown on Fig. 3 and must be so arranged that the following conditions are fulfilled:

- The total moment of force F_1 and the anchor force about O must be zero.
- The total moment of force F_2 and F_3 about O must be zero.
- The forces F_1 , F_2 and F_3 and the anchor force must balance.

When dealing with cohesive soils the correct penetration to fulfil these conditions is best determined by trial and error.

Larssen Steel Sheet Piling—Retaining Walls (continued)

The depth of penetration of the anchored sheet piling in cohesionless soil is given by the following formulae:

P (Penetration for fixed earth support)

$$= K \left[\bar{y} + \sqrt{\frac{6 R_o}{F_2}} \right]$$

where K = a factor, which is usually—

1.1 for angle ϕ greater than 25° .

1.2 for angle ϕ less than 25° .

$\bar{y}$ = Depth to line of support, see Fig. 3.

F₂ = Total nett passive resistance of the earth.

R_o = “equivalent beam” reaction at O.

The maximum B.M.

$$= \frac{F_1 \times L}{8} \quad \text{where } F_1 \text{ is the total active pressure,}$$

assumed uniformly distributed over the
“equivalent beam” span L

The force in the tie rod is found by taking moments above the point O. The position of point O is determined as for a cantilever wall.

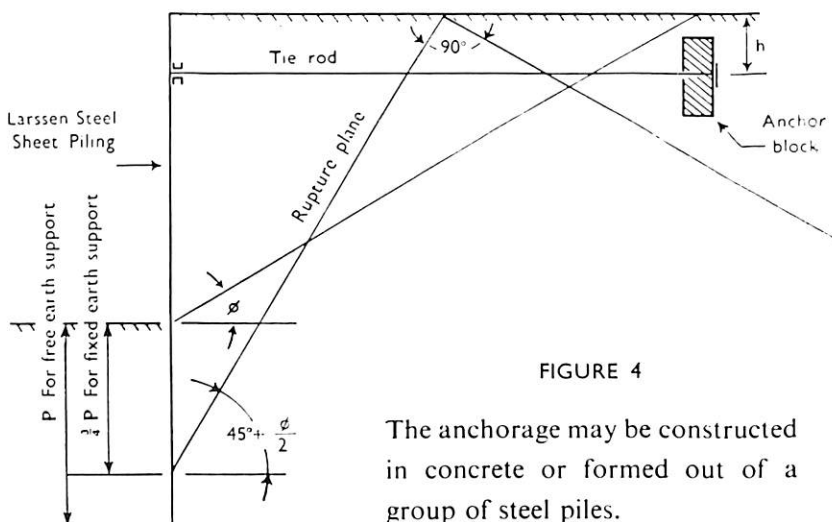
It is possible to reduce the maximum bending on piling retaining cohesionless soil by about 30% due to the arching action of the retained earth. However, this redistribution of moment causes an extra pull in the tie rod and it is good practice for the tie rod to be designed to cater for this additional pull. A further pull of say from 10% to 20% would not be considered unreasonable. A stress in the tie rod of 7 tons per sq. inch, and in the piling of 8 tons per sq. inch, is recommended.

WALINGS.

Tie rods are fastened to walings which are connected to the top of the sheet piling. The walings are designed as simply supported beams spanning between the tie rods and supporting a uniformly distributed load equal to the force in the tie rod. The spacing of the tie rods is governed somewhat by the amount of excavation that is required to instal the anchorages. If the tie rods are spaced far apart a heavy section for the waling will be required.

Where more than one set of walings and tie rods are used, that is, in cases where the bank of retained earth is very large, the piling should be designed between successive walings taking due account of the continuity provided.

DESIGN OF ANCHORAGE.



Larssen Steel Sheet Piling—Retaining Walls (continued)

Fig. 4 is constructed to give some guidance in the positioning of the anchorage block. The block should preferably be contained in the area bounded by the line drawn through angle ϕ where it is intersected by the line drawn at right angles to the plane of rupture.

According to Bell's formula the nett passive resistance of the earth in front of the block is given by

$$p_p = [w.h.k_p + 2.C\sqrt{k_p}] - [w.h.k_a - 2.C\sqrt{k_a}] \text{ lb/sq. ft.}$$
of anchorage where "h" is taken as being the depth to the centre of the anchor block.

The total earth resistance is found by multiplying the above expression by the area of the block. This resistance should be in excess of the force in the tie rod to allow a good factor of safety.

It is essential that the tie rods must be securely connected to both the piling and the anchorage. With long rods, a turnbuckle should be used to give the necessary adjustment to avoid forward creep of the wall during back filling.

Larssen Steel Sheet Piling—Retaining Walls (continued)

TIE RODS.

Standard Whitworth Screw Threads.

Safe Load on net area at 7 tons sq. in.

Diameter	Gross Area sq. inches	Area under Thread sq. inches	Safe Load in tons
$\frac{3}{4}$ " ...	·442	·304	2·12
$\frac{7}{8}$ " ...	·601	·422	2·95
1" ...	·785	·554	3·88
$1\frac{1}{8}$ " ...	·994	·697	4·88
$1\frac{1}{4}$ " ...	1·227	·894	6·25
$1\frac{3}{8}$ " ...	1·485	1·060	7·42
$1\frac{1}{2}$ " ...	1·767	1·300	9·10
$1\frac{5}{8}$ " ...	2·074	1·518	10·60
$1\frac{3}{4}$ " ...	2·405	1·753	12·30
$1\frac{7}{8}$ " ...	2·761	2·015	14·10
2" ...	3·142	2·311	16·20
$2\frac{1}{4}$ " ...	3·976	2·925	20·50
$2\frac{1}{2}$ " ...	4·909	3·732	26·10
$2\frac{3}{4}$ " ...	5·940	4·464	31·20
3" ...	7·069	5·450	38·20
$3\frac{1}{4}$ " ...	8·296	6·406	44·90
$3\frac{1}{2}$ " ...	9·621	7·577	53·00
$3\frac{3}{4}$ " ...	11·045	8·660	60·60
4" ...	12·566	10·030	70·20

If a higher stress than 7 tons per sq. inch is desired, the safe load is directly proportional to the stress chosen.

BEARING PILES.

FUNCTION.

The function of a bearing pile is to transmit the load, normally applied at the pile cap, to a stratum of material capable of supporting it without detrimental settlement over a long period of time.

CLASSIFICATION.

Piles may be classified by the manner in which they support the load. Piles which:

- (a) Act as a column passing through a weak material to a solid bearing stratum.
- (b) Support the load by friction between the surfaces of the pile and the surrounding material.
- (c) Transmit the load through weak material and support it by friction between the surfaces of the lower length of the pile and the stronger surrounding material.

BEARING CAPACITY OF PILES.

It would appear from experience in driving piles through deep layers of muds, silts and soft clays that no general rule for the bearing capacity of piles can be safely applied. Some will carry the load without showing undue settlement but others are not so satisfactory.

Larssen Steel Sheet Piling—Bearing Piles (continued)

The minimum length of friction piles should be at least equal to the width of structure they support unless they penetrate to a compact material.

There is often a considerable difference between the behaviour of a single pile and a group of piles and in designing a pile foundation it is not always sufficient to multiply the calculated load for a single pile by the total number of the piles in a group.

To prevent any risk of error, test piles should be driven and a complete soil mechanic investigation of the material and strata undertaken in order that the most suitable type of foundation may be chosen and designed.

If possible, the test load should be applied to several piles, say four, and the remaining piles driven to the same level as the test piles. The test load should be applied for a reasonable length of time in order that the material through which the piles are driven can adjust itself to the new conditions.

RESISTANCE OF BEARING PILES.

To find the resistance developed by the ground, formulae may be used or loading tests may be carried out. Loading tests give more reliable results but take time and are necessarily expensive.

There are many pile formulae in existence but the most rational and widely used is the Hiley formula. It is based on the laws governing impact of elastic bodies. Its limitation lies in calculating the resistance of piles in silts, muds and soft clays.

Larssen Steel Sheet Piling—Bearing Piles (continued)

Much better comparison between calculated and actual bearing capacity is obtained by this formula in compact soils and gravels and under these conditions it gives reliable results.

Re-driving the piles after a period of rest of not less than 12 hours will give an indication of the reliability of the formula.

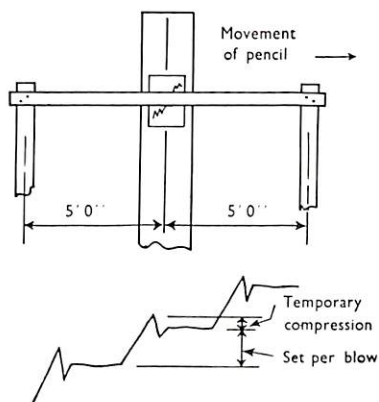
If there is a marked difference between the set, or penetration of the pile per blow, for the first few blows when driving is re-commenced and the set for the last few blows when the pile was originally driven, the material is likely to alter its resistance with time and therefore the dynamic formula is not suitable.

When the nature of the ground is in doubt test piles should be driven and loaded.

Test loads of short duration are not recommended as they may give a wrong indication of the ultimate settlement when the piles are supporting their working load.

TEMPORARY COMPRESSION.

The value of temporary compression should be obtained when about $\frac{2}{3}$ the length of the pile has been driven by fixing a card to the pile near the head, erecting a trestle on the ground, well clear of the pile so as to avoid any ground movement, and drawing a pencil across a straight edge positioned near the card, during a blow. This should be done for the last blow for each foot of penetration until the pile meets refusal.



THE HILEY FORMULA.

$$R = \frac{\eta W h}{S + \frac{C}{2}}$$

Where R = Ultimate resistance of ground, in tons.

P = Weight of pile + driving cap, anvil, helmet or any other dead weight moving with pile, in tons.

W = Weight of hammer, ram or any other appliance delivering blow, in tons.

e = Coefficient of restitution.

η = Efficiency of hammer blow, which depends upon the nature of the material, the coefficient of restitution and the ratio $\frac{P}{W}$

Where the pile is driven into penetrable ground

$$\eta = \frac{W + Pe^2}{W + P}$$

Where the pile is driven to refusal

$$\eta = \frac{W + 0.5 Pe^2}{W + 0.5 P}$$

H = Actual stroke of hammer or ram, in inches.

h = Equivalent height of free fall of ram.

$$h = \begin{cases} 1.0 H & \text{For drop hammer released by trigger.} \\ 0.9 H & \text{For single acting steam hammer.} \\ 0.8 H & \text{For winch-operated drop hammer} \\ & \text{actuated by wire rope.} \\ \frac{H(W + a.m.)}{W} & \text{For double acting steam hammer,} \\ & \text{where,} \\ & a = \text{Area of piston in sq. inches.} \\ & m = \text{mean effective pressure in} \\ & \text{tons per square inch.} \end{cases}$$

S = Set per hammer blow, *i.e.* penetration of pile per blow, in inches.

C = Temporary compression of pile per hammer blow.

F = Factor of safety.

R_2 = Total resistance of ground = $R + W + P$

L = Safe working load on pile = $\frac{R_2}{F} - P$

TABLE I.
EFFICIENCY OF BLOW.

$$\eta = \frac{W + Pe^2}{W + P}$$

Ratio of $\frac{P}{W}$		Case I $e = 0.5$	Case II $e = 0.32$
$\frac{1}{2}$	...	0.75	0.70
1	...	0.63	0.55
$1\frac{1}{2}$	...	0.55	0.46
2	...	0.50	0.40
$2\frac{1}{2}$	...	0.45	0.36
3	...	0.42	0.33
4	...	0.36	0.28
5	...	0.31	0.25
6	...	0.27	0.23

Case I, Double acting hammers driving steel piles without helmet.

Case II, Single acting hammers and drop hammers driving steel box piles with helmet and short dolly.

$$\frac{P}{W} = \frac{\text{Weight of pile} + \text{anvil, etc.}}{\text{Weight of hammer or ram}}$$

TABLE II.
TEMPORARY COMPRESSIONS IN INCHES
FOR STEEL PILES.

Length of pile in feet		Col. I	Col. II
20	...	0.22	0.29
30	...	0.28	0.41
40	...	0.34	0.53
50	...	0.40	0.65
60	...	0.46	0.77
70	...	0.52	0.89
80	...	0.58	1.01
90	...	0.64	1.13
100	...	0.70	1.25

When piles are driven down to solid rock or very hard material no allowance for temporary compression need be made.

MEDIUM DRIVING.

Col. I is for driving resistances of 1,000 lbs. per sq. in. on total cross sectional area and 15,000 lbs. per sq. in. on cross sectional area of steel for open ended piles.

HARD DRIVING.

Col. II is for driving resistances of 2,000 lbs. per sq. in. on total cross sectional area and 30,000 lbs. per sq. in. on cross sectional area of steel for open ended piles.

Larssen Steel Sheet Piling—Bearing Piles (continued)

Example :

A 60' 0" long Larssen box pile No. B.P.5 section is to be driven open ended through permeable material to hard compact sand. It is required to find the safe load the pile is capable of carrying with a factor of safety of 2 when the estimated final penetration is 1" for the last 10 blows using a 3 ton drop hammer.

Weight of pile and driving cap, $P = 3.6^r + 0.4^r = 4$ tons

Weight of hammer, $W = 3$ tons

Free fall of hammer, $h = 48$ ins.

Penetration, $S = \frac{1}{10} = 0.1$ inch

Efficiency of blow η from Table I.

$$\frac{P}{W} = \frac{4^r}{3^r} = 1.33, \eta = 0.49$$

Temporary compression, from Table II.

$$C = 0.46$$

Ultimate resistance of ground.

$$R = \frac{\eta Wh}{S + \frac{C}{2}} = \frac{0.49 \times 3 \times 48}{0.1 + 0.23} = \underline{214 \text{ tons}}$$

Total resistance of ground.

$$R_2 = R + W + P = 214 + 3 + 4 = 221 \text{ tons}$$

$$\text{Safe load} = \frac{221}{2} - 4 = \underline{106.5 \text{ tons}}$$

THE METRIC SYSTEM.

Linear Measure.

1 inch	= 25.400 millimetres	1 millimetre	= 0.03937 inch
1 foot	= 0.3048 metre	1 centimetre	= 0.3937 inch
1 yard	= 0.9144 metre	1 metre	= $\begin{cases} 3.2808 \text{ feet} \\ 1.0936 \text{ yards} \end{cases}$
1 furlong	= 201.168 metres	1 kilometre	= 0.6214 mile
1 mile	= 1.6093 kilometres		

Square Measures.

1 sq. inch	= 6.4516 sq. cm.	1 sq. cm.	= 0.1550 sq. in.
1 sq. foot	= 9.2903 sq. dm.	1 sq. m.	= $\begin{cases} 10.7639 \text{ sq. ft.} \\ 1.1960 \text{ sq. yds.} \end{cases}$
1 sq. yard	= 0.8361 sq. m.	1 are	= 119.6 sq. yds.
1 acre	= 0.4047 hectare	1 hectare	= 2.4711 acres
1 sq. mile	= 259.00 hectares		

Cubic Measurement.

1 cubic inch	= 16.387 cubic cm.	1 cubic cm.	= 0.0610 cubic in.
1 cubic foot	= 0.0283 cubic m.	1 cubic dm.	= 61.024 cubic ins.
1 cubic yard	= 0.7646 cubic m.	1 cubic m.	= $\begin{cases} 35.3147 \text{ cu. ft.} \\ 1.308 \text{ cu. yds.} \end{cases}$

Measure of Capacity.

1 pint	= 0.568 litre	1 centilitre	= 0.07 gill
1 quart	= 1.136 litres	1 decilitre	= 0.176 pint
1 gallon	= 4.546 litres	1 litre	= 1.7598 pints

Weight.

1 oz.	= 28.350 grammes	1 gramme	= 0.0353 oz.
1 pound	= 0.4536 kilogram	1 kilogram	= 2.2046 lbs.
1 ton	= 1.016 tonnes	1 tonne	= 0.9842 ton
	= 1,016 kilograms		

INCHES IN DECIMALS OF A FOOT.

Inches	Foot	Inches	Foot	Inches	Foot	Inches	Foot
0	.0000	$\frac{1}{32}$	.0286	$\frac{1}{16}$	.0573	2	.1667
	.0026	$\frac{3}{8}$	.0313	$\frac{3}{32}$	.0599	3	.2500
$\frac{1}{16}$	.0052	$\frac{13}{32}$	.0339	$\frac{3}{4}$	.0625	4	.3333
	.0078	$\frac{7}{16}$	.0365		$\frac{25}{32}$	5	.4167
$\frac{1}{8}$	.0104	$\frac{15}{32}$	.0391	$\frac{13}{16}$	.0677	6	.5000
	.0130	$\frac{1}{2}$	.0417	$\frac{27}{32}$	.0703	7	.5833
$\frac{3}{16}$	.0156	$\frac{17}{32}$	.0443	$\frac{7}{8}$	.0729	8	.6667
	.0182	$\frac{9}{16}$	.0469	$\frac{29}{32}$	.0755	9	.7500
$\frac{1}{4}$	.0208	$\frac{19}{32}$	.0495	$\frac{15}{8}$	.0781	10	.8333
	.0234	$\frac{5}{8}$	.0521	$\frac{31}{32}$	.0807	11	.9167
$\frac{5}{16}$	.0260	$\frac{21}{32}$	.0547	1	.0833	12	1.0000

CONVERSION FACTORS AND CONSTANTS.

Modulus of Section in cm. units	=	16·3871	×	modulus in inch units
Moment of Inertia in cm. units	=	41·6231	×	moment in inch units
Modulus of Section in cm. units per metre	=	53·763	×	modulus of section in inch units per foot
1 Cubic yard		=	0·7645	cubic metres.
1 Kilogram per lineal metre		=	0·6720	pounds per lineal foot
1 Kilogram per sq. cm.	..	=	14·223	pounds per sq. inch
1 Kilogram per sq. mm.	..	=	0·6350	tons per sq. inch
1 Kilogram per sq. metre	..	=	0·2048	pounds per sq. ft.
1 Foot pound		=	0·1383	kilogrammetres
1 H.P. (English)		=	0·746 kilowatts	= 33,000 foot- lbs. per minute
1 Atmosphere		=	14·7	lbs. per sq. inch
1 Radian		=	57·3	degrees
Value of "g" at London	..	=	32·18	feet per second per second
Absolute temperature	..	=	— 273°	C.
1 United States gallon	..	=	0·83	British gallon
1 cubic foot of fresh water	..	=	6·24	British gallons
Head of fresh water in ft. × 0·433		=		Pressure in lbs. per sq. inch
Head of sea water in ft. × 0·444		=		Pressure in lbs. per sq. inch
1 cubic foot of sea water	..	=	64 lbs.	= ·0286 tons
1 lb. water evaporated at 212° F.		=	1·180	British Thermal Units.
		=	124,200 kg.m.	= 887,800 ft. lbs.
1 Imperial bushel		=	1·2843	cu. ft.

NATURAL TRIGONOMETRICAL FUNCTIONS.

Angle	Radian	Sine	Tangent	Co-tangent	Cosine	
0°	0	0	0	∞	1	90°
1	·0175	·0175	·0175	57·2900	·9998	1·5708
2	·0349	·0349	·0349	28·6363	·9994	1·5533
3	·0524	·0523	·0524	19·0811	·9986	1·5359
4	·0698	·0698	·0699	14·3006	·9976	1·5184
5	·0873	·0872	·0875	11·4301	·9962	1·5010
6	·1047	·1045	·1051	9·5144	·9945	1·4835
7	·1222	·1219	·1228	8·1443	·9925	1·4661
8	·1396	·1392	·1405	7·1154	·9903	1·4486
9	·1571	·1564	·1584	6·3138	·9877	1·4312
10	·1745	·1736	·1763	5·6713	·9848	1·4137
11	·1920	·1908	·1944	5·1446	·9816	1·3963
12	·2094	·2079	·2126	4·7046	·9781	1·3788
13	·2269	·2250	·2309	4·3315	·9744	1·3614
14	·2443	·2419	·2493	4·0108	·9703	1·3439
15	·2618	·2588	·2679	3·7321	·9659	1·3265
16	·2793	·2756	·2867	3·4874	·9613	1·3090
17	·2967	·2924	·3057	3·2709	·9563	1·2915
18	·3142	·3090	·3249	3·0777	·9511	1·2741
19	·3316	·3256	·3443	2·9042	·9455	1·2566
20	·3491	·3420	·3640	2·7475	·9397	1·2392
21	·3665	·3584	·3839	2·6051	·9336	1·2217
22	·3840	·3746	·4040	2·4751	·9272	1·2043
						1·1868

23	.4014	.3907	.4245	2.3559	.9205	1.1694	67
24	.4189	.4607	.4452	2.2460	.9135	1.1519	66
25	.4363	.4226	.4663	2.1445	.9063	1.1345	65
26	.4538	.4384	.4877	2.0503	.8988	1.1170	64
27	.4712	.4540	.5095	1.9626	.8910	1.0996	63
28	.4887	.4695	.5317	1.8807	.8830	1.0821	62
29	.5061	.4848	.5543	1.8040	.8746	1.0647	61
30	.5236	.5000	.5774	1.7321	.8660	1.0472	60
31	.5411	.5150	.6009	1.6643	.8572	1.0297	59
32	.5585	.5299	.6249	1.6003	.8480	1.0123	58
33	.5760	.5446	.6494	1.5399	.8387	.9948	57
34	.5934	.5592	.6745	1.4826	.8290	.9774	56
35	.6109	.5736	.7002	1.4281	.8192	.9599	55
36	.6283	.5878	.7265	1.3764	.8090	.9425	54
37	.6458	.6018	.7536	1.3270	.7986	.9250	53
38	.6632	.6157	.7813	1.2799	.7880	.9076	52
39	.6807	.6293	.8098	1.2349	.7771	.8901	51
40	.6981	.6428	.8391	1.1918	.7660	.8727	50
41	.7156	.6561	.8693	1.1504	.7547	.8552	49
42	.7330	.6691	.9004	1.1106	.7431	.8378	48
43	.7505	.6820	.9325	1.0724	.7314	.8203	47
44	.7679	.6947	.9657	1.0355	.7193	.8029	46
45	.7854	.7071	1.0000	1.0000	.7071	.7854	45
							Angle
							Radian
							Sine
							Tangent
							Co-tangent
							Cosine

WEIGHT AND STRENGTH OF MATERIALS.

Material	lbs. per cu. ft.	Ultimate Strength tons per sq. in.			Yield Point	Safe Stress tons per sq. in.	Modulus of Elasticity
		Tension	Com- pression	Shear			
Cast Iron	450	9	50	8	—	3	6,500
Malleable C.I.	450	18	—	—	—	—	—
Wrought Iron	480	22	17	20	12	6	12,500
Cable Iron	485	23	20	22	14	7	13,000
Mild Steel	490	28	30	24	16	8	13,000
Cast Steel	490	26	30	18	17	9	13,000
Spring Steel	490	85	85	—	65	35	14,000
Gun Metal	540	14	30	10	8	—	5,000
Naval Brass	530	22	—	—	11	—	—
Phosphor Bronze	536	17	—	14	10	—	6,000
Manganese Bronze	—	35	—	—	—	—	—
Lead	710	1	3	—	—	—	1,000
Duralumin	175	28	—	—	15	—	5,000

WEIGHT AND STRENGTH OF TIMBER.

Name	Weight per cu. ft.	Ultimate Strength tons per sq. inch		Modulus of Elasticity tons/sq. in.
		Tension	Compression (with grain)	
Ash	lbs. 48	4.5	4	700
English Elm ...	35	2.7	3	700
Canadian Elm ...	45	4	4	700
Spruce	30	2	3	500
Larch	35	4	3	500
Oak	55	5.5	4.5	700
Beech	48	5	3.8	600
Pitch Pine ...	45	3	3	800
Yellow Pine ...	30	1	2	650
Red Pine	34	1	2	600
Greenheart ...	70	6	8	500
Hickory	50	3	4	800
Lignum Vitae ...	78	6	8	800
Bamboo	20	3	5	900
Ironwood	50	6	8	800
Blue Gum	74	7	3.5	—
Teak	45	2	4	800
Sabicu	57	2.5	4	1,100

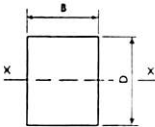
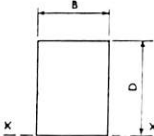
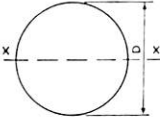
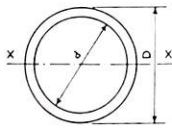
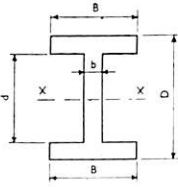
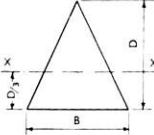
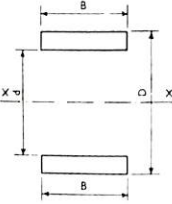
CUBIC FEET PER FOOT RUN.

Size	Cub. ft.	Size	Cub. ft.	Size	Cub. ft.
2 $\frac{1}{2}$ " $\times$ 1"	0.0156	8" $\times$ 8"	0.4445	13" $\times$ 13"	1.1735
3" $\times$ 2"	0.0417	8" $\times$ 8 $\frac{1}{2}$ "	0.4722	13" $\times$ 13 $\frac{1}{2}$ "	1.2187
4" $\times$ 2"	0.0556	8 $\frac{1}{2}$ " $\times$ 7 $\frac{1}{2}$ "	0.4427	13 $\frac{1}{2}$ " $\times$ 13 $\frac{1}{2}$ "	1.2656
4" $\times$ 3"	0.0833	9" $\times$ 3"	0.1875	14" $\times$ 14"	1.3612
4" $\times$ 4"	0.1111	9" $\times$ 6"	0.3750	14" $\times$ 14 $\frac{1}{2}$ "	1.4097
4 $\frac{1}{2}$ " $\times$ 4 $\frac{1}{2}$ "	0.1406	9" $\times$ 8 $\frac{1}{2}$ "	0.5312	14 $\frac{1}{2}$ " $\times$ 14 $\frac{1}{2}$ "	1.4600
5" $\times$ 2 $\frac{1}{2}$ "	0.0868	9" $\times$ 9"	0.5625	15" $\times$ 14 $\frac{1}{2}$ "	1.5104
5" $\times$ 3"	0.1042	9" $\times$ 12"	0.7500	15" $\times$ 15"	1.5625
5" $\times$ 5"	0.1736	10" $\times$ 9 $\frac{1}{2}$ "	0.6597	15 $\frac{1}{2}$ " $\times$ 14 $\frac{1}{2}$ "	1.5608
5 $\frac{1}{2}$ " $\times$ 5 $\frac{1}{2}$ "	0.2100	10" $\times$ 10"	0.6944	15 $\frac{1}{2}$ " $\times$ 15 $\frac{1}{2}$ "	1.6685
6" $\times$ 2"	0.0834	10" $\times$ 10 $\frac{1}{2}$ "	0.7291	16" $\times$ 8"	0.8889
6" $\times$ 3"	0.1250	10 $\frac{1}{2}$ " $\times$ 9 $\frac{1}{2}$ "	0.6927	16" $\times$ 12"	1.3333
6" $\times$ 4"	0.1667	11" $\times$ 4"	0.3055	16" $\times$ 15 $\frac{1}{2}$ "	1.7222
6" $\times$ 5 $\frac{1}{2}$ "	0.2292	11" $\times$ 10 $\frac{1}{2}$ "	0.8021	16" $\times$ 16"	1.7777
6" $\times$ 6"	0.2500	11" $\times$ 11"	0.8403	16 $\frac{1}{2}$ " $\times$ 16 $\frac{1}{2}$ "	1.8906
7" $\times$ 3"	0.1458	11" $\times$ 11 $\frac{1}{2}$ "	0.8785	18" $\times$ 6"	0.7500
7" $\times$ 7"	0.3402	11 $\frac{1}{2}$ " $\times$ 10 $\frac{1}{2}$ "	0.8385	18" $\times$ 9"	1.1250
7" $\times$ 7 $\frac{1}{2}$ "	0.3646	11 $\frac{1}{2}$ " $\times$ 11 $\frac{1}{2}$ "	0.9183	18" $\times$ 12"	1.5000
7 $\frac{1}{2}$ " $\times$ 7 $\frac{1}{2}$ "	0.3906	12" $\times$ 3"	0.2500	18" $\times$ 17"	2.1251
8" $\times$ 2 $\frac{1}{2}$ "	0.1389	12" $\times$ 6"	0.5000	18" $\times$ 18"	2.2500
8" $\times$ 3"	0.1667	12" $\times$ 11 $\frac{1}{2}$ "	0.9583	18" $\times$ 19"	2.3750
8" $\times$ 4"	0.2222	12" $\times$ 12"	1.0000	20" $\times$ 19"	2.6389
8" $\times$ 5 $\frac{1}{2}$ "	0.3055	12" $\times$ 12 $\frac{1}{2}$ "	1.0417	20" $\times$ 20"	2.7779
8" $\times$ 6"	0.3334	12 $\frac{1}{2}$ " $\times$ 11 $\frac{1}{2}$ "	0.9983	20" $\times$ 21"	2.9167
8" $\times$ 7 $\frac{1}{2}$ "	0.4167	13" $\times$ 12 $\frac{1}{2}$ "	1.1285	24" $\times$ 24"	4.0000

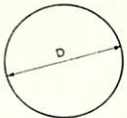
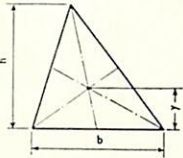
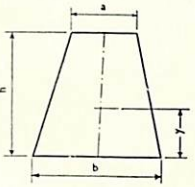
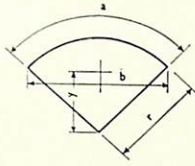
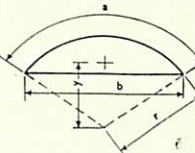
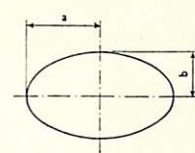
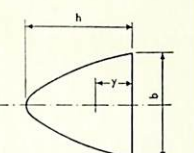
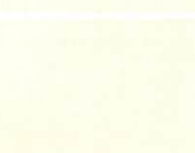
BENDING MOMENTS IN BEAMS.

Type	Total Load W	Maximum Bending Moment	Maximum Deflection
Cantilever	Concentrated at End	WL	$\frac{WL^3}{3EI}$
	Uniformly Distributed	$\frac{WL}{2}$	$\frac{WL^3}{8EI}$
Freely Supported	Concentrated at Centre	$\frac{WL}{4}$	$\frac{WL^3}{48EI}$
	Uniformly Distributed	$\frac{WL}{8}$	$\frac{5WL^3}{384EI}$
	Varying uniformly from zero at one end to a maximum at other end	$0.128WL$	$0.013 \frac{WL^3}{EI}$
One end fixed, other end freely supported	Concentrated at Centre	$\frac{3WL}{16}$	$0.00932 \frac{WL^3}{EI}$
	Uniformly Distributed	$\frac{WL}{8}$	$0.0054 \frac{WL^3}{EI}$
Both Ends Fixed	Concentrated at Centre	$\frac{WL}{8}$	$\frac{WL^3}{192EI}$
	Uniformly Distributed	$\frac{WL}{12}$	$\frac{WL^3}{384EI}$

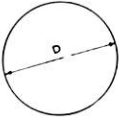
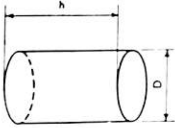
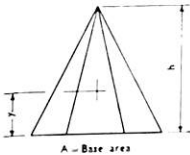
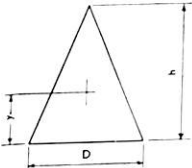
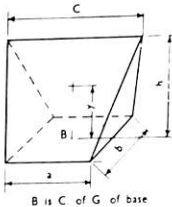
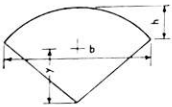
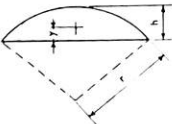
PROPERTIES OF SECTIONS.

Section	Moment of Inertia	Section Modulus
	$\frac{BD^3}{12}$	$\frac{BD^2}{6}$
	$\frac{BD^3}{3}$	—
	$\frac{\pi D^4}{64}$	$\frac{\pi D^3}{32}$
	$\frac{\pi (D^4 - d^4)}{64}$	$\frac{\pi (D^4 - d^4)}{32D}$
	$\frac{BD^3 - (B-b)d^3}{12}$	$\frac{BD^3 - (B-b)d^3}{6D}$
	$\frac{BD^3}{36}$	$\frac{BD^2}{24}$
	$\frac{B (D^3 - d^3)}{12}$	$\frac{B (D^3 - d^3)}{6D}$

MENSURATION OF PLANE SURFACES.

Figure	Description	Area	Distance y to Centre of Gravity
	Circle	$0.7854 D^2$	At centre
	Triangle	$\frac{1}{2} bh$	$\frac{h}{3}$ at intersection of median lines
	Trapezoid or Parallelogram	$\frac{1}{2} (a + b) h$	$\frac{h (2a + b)}{3 (a + b)}$
	Circular Arc	—	$\frac{br}{a}$
	Circular Sector	$\frac{1}{2} ar$	$\frac{2 br}{3 a}$
	Circular Segment	$\frac{ar}{2} - \frac{b}{2} (r-h)$	$\frac{b^3}{12 \times \text{Area}}$
	Ellipse	$3.1416 ab$	At centre
	Parabolic Segment	$\frac{2}{3} bh$	$\frac{2}{5} h$

MENSURATION OF SOLIDS.

Figure	Description	Surface A or Volume V	Distance y to Centre of Gravity
	Sphere	$A = 3.1416 D^2$ $V = 0.5236 D^3$	At centre
	Cylinder	Curved Surface $A = 3.1416 Dh$ $V = 0.7854 D^2h$	At centre
	Pyramid	$V = \frac{1}{3} Ah$	$\frac{h}{4}$ above base
	Cone	Curved Surface $A = 0.7854 D \times$ $\times \sqrt{4h^2 + D^2}$ $V = 0.2618 D^2h$	$\frac{h}{4}$ above base
	Wedge	$V = \frac{bh}{6} (2a + c)$	$\frac{h(a+c)}{2(2a+\frac{1}{2}c)}$
	Spherical Sector	Total Surface $A = 3.1416 r \times$ $(2h + \frac{1}{2}b)$ $V = 2.0944 r^2h$	$\frac{3}{4} \left(r - \frac{h}{2} \right)$
	Spherical Segment	Spherical Surface $A = 6.2832 rh$ $V = 1.0472 h^2 \times$ $(3r-h)$	$\frac{h(4r-h)}{4(3r-h)}$

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MANCHESTER

Midland Bank House, Cross Street, 2
Telephone: Blackfriars 3647-8
Telegrams: " Soudurham," Phone, Manchester

NEWCASTLE UPON TYNE

Rochester Chambers, 26 Collingwood Street, 1
Telephone: Newcastle 21867 and 24832
Telegrams: " Soudurham," Phone, Newcastle

GLASGOW

68 Bath Street, Glasgow, C.2
Telephone: Douglas 1880
Telegrams: " Soudurham," Phone, Glasgow

OVERSEAS AGENCIES THROUGHOUT THE WORLD

SOUTH DURHAM STEEL & IRON COMPANY LIMITED

(Incorporating Cargo Fleet Iron Company Limited)

PRINCIPAL PRODUCTS OF THE COMPANY

CARGO FLEET IRON WORKS, MIDDLESBROUGH

STEEL RAILS AND FISHPLATES, JOISTS AND SECTIONS
BROAD FLANGE BEAMS WITH PARALLEL FLANGES
UNIVERSAL BEAMS, COLUMNS AND BEARING PILES
LARSEN STEEL PILING
"RENDHEX" FOUNDATION COLUMNS

'NORTH' WORKS, WEST HARTLEPOOL

'SOUTH' WORKS, GREATHAM

MILD STEEL PLATES (Tank, Ship and Boiler)
HIGH TENSILE STEEL PLATES
DURBAR NON-SLIP RAISED PATTERN FLOOR PLATES
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MALLEABLE WORKS, STOCKTON-ON-TEES

STEEL PIPES (From 16" up to 96" diameter and up to
40 feet in length)
STRUCTURAL STEELWORK
WELDED STEEL TANKS AND PRESSURE VESSELS
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